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## THE DEVELOPMENT OF THE SELF-EFFICACY OF BALANCE SCALE (SEBS): INVESTIGATION OF PSYCHOMETRIC PROPERTIES IN FEMALE BASKETBALL PLAYERS

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THE DEVELOPMENT OF THE SELF-EFFICACY OF BALANCE SCALE (SEBS):  
INVESTIGATION OF PSYCHOMETRIC PROPERTIES IN FEMALE  
BASKETBALL PLAYERS

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DISSERTATION

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A dissertation submitted in partial fulfillment of the  
requirements for the degree of Doctor of Philosophy in the  
College of Health Sciences at the University of Kentucky

By  
Carrie Silkman Baker  
Lexington, Kentucky

Director: Dr. Jennifer McKeon, Assistant Professor of Athletic Training  
Lexington, Kentucky

2012

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## ABSTRACT OF DISSERTATION

### THE DEVELOPMENT OF THE SELF-EFFICACY OF BALANCE SCALE (SEBS): INVESTIGATION OF PSYCHOMETRIC PROPERTIES IN FEMALE BASKETBALL PLAYERS

Lower extremity injuries are the most common sports related injury. Many steps have been taken to attempt to identify individuals who might be at a higher risk for sustaining a lower extremity injury. Resource and time intensive screening techniques have been used previously to attempt to identify such individuals. However these techniques have focused heavily on postural control and landing mechanics in athletes, no psychological measure has been used to identify individuals who might be at a higher risk of lower extremity injury.

Self-efficacy of balance can be defined as how capable an individual feels he or she can balance in different scenarios. Research in the balance deficient population (elderly, post-stroke, knee osteoarthritis) has revealed that self-efficacy of balance is a quantifiable psychological component of balance related behavior. As previously stated, current screening techniques for lower extremity injuries do not incorporate psychological measures. Research suggests that psychological indicators of balance confidence are important to measure in conjunction with balance test performance to establish the relationship between the two constructs. Assessment of these factors is necessary to examine how psychological measures affect performance on tests used in clinical balance assessments.

The objective of this dissertation was to develop the Self-Efficacy of Balance Scale (SEBS), a psychometrically sound self-efficacy of balance instrument for use in the young, active population. The relationship between self-efficacy of balance and self-reported measures of lower extremity function, and clinical and laboratory measures of balance were also examined in the young, active population. It was hypothesized that a valid, reliable, responsive tool could be created to accurately and precisely measure self-efficacy of balance in a

young, active population. In addition, it was hypothesized that high levels of self-efficacy of balance would have a significant, positive relationship with self-reported measure of lower extremity function, and clinical and laboratory measure of balance.

Results from the three studies brought about several interesting observations. Studies one, two, and three demonstrated evidence of a psychometrically sound instrument. This indicates that the SEBS is a valid, reliable, responsive self-efficacy of balance instrument when evaluating young, active individuals. Study three demonstrated the relationships between self-efficacy of balance and self-reported measures of function, and objective measures of balance. These relationships revealed that while lower extremity function and some measures of balance influence scores of the SEBS, they do not account for all of the variability of the SEBS. This finding further supports the claim that balance behavior is changing as function and postural control change. Therefore, future research should include investigation regarding the utility of the SEBS, as well as longitudinal studies to establish effectiveness of identifying individuals at a higher risk of sustaining a lower extremity injury.

KEYWORDS: self-efficacy, self-efficacy scale, balance, lower extremity, function

Carrie Silkman Baker

Student's Signature

April 4, 2012

Date

THE DEVELOPMENT OF THE SELF-EFFICACY OF BALANCE SCALE (SEBS):  
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### BACKGROUND

Injury prevention is a central goal of both clinicians and researchers. Many researchers have investigated the effectiveness of lower extremity injury prevention programs<sup>1-21</sup> to reduce injury or decrease lower extremity injury risk factors. However, to decrease injury or risk of injury, it is important to understand the causal link between the individual and the injury. Decreased proprioception, postural stability, strength, anatomical malalignment, and sex have been identified as risk factors for lower extremity injuries<sup>22, 23</sup>. Poor postural stability, or balance, has been shown to be a predictor of lower extremity injury, specifically of the ankle<sup>22</sup>. Knee injuries, primarily non-contact anterior cruciate ligament (ACL) injuries, have been attributed to decreased neuromuscular control of the lower limb<sup>24, 25</sup> and decreased neuromuscular control of the trunk<sup>3, 15, 25</sup>. These particular risk factors identified are modifiable. Therefore if an individual is identified as having a known risk factor, it is possible to decrease the impact of the risk factor through an intervention.

Several methods have been developed to identify individuals who might be at a higher risk for sustaining a lower extremity injury<sup>24-29</sup>. Current screening techniques employed to identify modifiable risk factors require time, space, and equipment to screen individuals. These techniques aim to identify biomechanic and/or neuromuscular risk factors. However, sport injuries to the lower extremity are multifactorial in nature<sup>30</sup>. Risk factors for lower extremity injury are not limited to biomechanic and/or neuromuscular factors, but can also be psychological in nature<sup>31</sup>. To understand the complex nature of injury, it is important to examine all aspects of potential risk factors. The effectiveness of identification of biomechanic and/or neuromuscular lower extremity risk factors has been investigated. However, evaluation of psychological factors has not been included in these prospective investigations.

Psychological factors, such as self-confidence, are thought to influence physical performance through one's perception of abilities<sup>32-35</sup>. Self-confidence is often identified as a common mechanism for athletic achievement<sup>32</sup>. Situation

specific self-confidence can also be referred to as self-efficacy<sup>32</sup>. Self-efficacy, a self-regulatory mechanism, is considered an individual's perception of his or her capabilities to successfully complete specific tasks or perform in a specific situation<sup>36</sup>. Within the construct of self-efficacy, individuals have the ability to contribute to their own motivation and action<sup>37-39</sup>. Self-efficacy can influence the outcome an individual expects his or her efforts will produce. If an individual has high self-efficacy regarding a particular task and that task resulted in a poor performance, the individual would likely attribute the poor performance to a lack of effort. The individual possessed the required capability to perform the task, lack of effort resulted in a poor outcome. Self-efficacy can also influence the amount of effort and level of persistence an individual will expend to complete a given task, as well as perseverance to overcome any obstacles he or she might face in completing the task<sup>40-43</sup>.

Four sources of information can shape self-efficacy: 1) Performance accomplishments, 2) vicarious experiences, 3) social or verbal persuasions, and 4) emotional and physiological states<sup>40</sup>. Performance accomplishments are considered particularly influential in developing self-efficacy as they are based on past experiences. If an individual has repeated success with limited failure, self-efficacy will increase, as will drive to overcome future failure or obstacles<sup>43</sup>. Previous research has demonstrated that high physical self-efficacy is positively related to better physical performance in accuracy, endurance, and overall performance outcome.<sup>44-46</sup>

Recently, the influence of injury on self-efficacy has been explored in athletes who have sustained anterior cruciate ligament (ACL) injuries<sup>47, 48</sup>. A knee self-efficacy scale (K-SES) was created to evaluate individuals' perceived self-efficacy of knee function in patients who had sustained an ACL injury<sup>49</sup>. It was demonstrated that patients' preoperative self-efficacy of knee function predicted post-surgical self-reported and objective outcomes of knee function<sup>48</sup>. One year following surgery, individuals with high levels of knee function self-efficacy had better outcomes than those with lower levels of knee function self-efficacy. While this model is important in regards to identifying individuals that

might have better outcomes following surgery, the information does not help to identify those at risk for a knee injury. The relationship between self-efficacy and outcomes following injury exists. However, self-efficacy has not yet demonstrated predictive capabilities individuals at a higher risk of injury.

There is a paucity of information about the role of self-efficacy in relation to lower extremity injury prevention or reduction of the risk of injury in young, active individuals<sup>50</sup>. Evidence of the relationship between self-efficacy of balance and postural control exists within the elderly population<sup>51-54</sup>, the knee osteoarthritis population<sup>55</sup>, as well as the post-stroke population<sup>56</sup>. In these studies, balance confidence represents a quantifiable psychological component of balance related behavior<sup>57</sup>. A consistent, positive relationship between self-efficacy of balance and risk of injury has been established in these populations. High levels of self-efficacy of balance are associated with high levels of physical function and measures of balance<sup>57, 58</sup>. Low balance self-efficacy is related to poor balance, increased fall risk, restriction of activity, loss of independence and reduced quality of life in these balance deficient populations<sup>57, 59, 60</sup>. However, this relationship has only been investigated in the balance deficient population.

Though the relationship between balance and self-efficacy was established is in the balance deficient population, further exploration of the relationship between balance and self-efficacy in the young, active population is merited. Lower extremity injuries are the most common sports related injury, with the ankle accounting for 40%, knee 25%, and thigh 14% of the most frequently injured areas<sup>61</sup>. An average of 375,350 basketball-related injuries were treated in US emergency departments per year between 1997 through 2007<sup>62</sup>. According to injury tracking data, basketball players have the second highest lower extremity injury rate for males and females<sup>61</sup>. Females incurred more season-ending lower extremity injuries, and twice as many knee injuries requiring surgery than their male counterparts<sup>61, 63</sup>. There is a need for lower extremity injury reduction in the young, active population. Establishing a link between balance and self-efficacy might help to further explain the risk of injury in the lower extremity and aid in prevention of lower extremity injuries.

There are several balance self-efficacy scales that have been utilized within the balance deficient population<sup>64</sup>. The Activities-specific Balance Confidence (ABC) scale is a commonly used measure that addresses levels of balance confidence during activities of daily living in older adults<sup>64</sup>. While this scale addresses balance confidence, it examines every day tasks, such as sweeping the floor and shopping, and might not be sensitive enough to assess balance confidence in young, active individuals. A measurement instrument that is valid, reliable, and responsive, which addresses fundamental activities of an active individual is needed to assess balance self-efficacy in a young, active population.

#### STATEMENT OF THE PROBLEM

Sports injuries resulted in 2.5 million visits annually, or 23% of emergency department injury related visits<sup>65</sup>. Injury to the lower extremity is the most common of sports injuries<sup>61</sup>. Screening methods exist for identification of biomechanical and neuromuscular control risk factors for lower extremity injuries, however there are no current screening methods that address the psychological aspect of risk factors for lower extremity injury.

Psychological indicators of balance confidence are important to measure in conjunction with balance test performance to establish the relationship between the two constructs in the young, active population<sup>57</sup>. Research suggests that injury reduction is not feasible without some kind of behavioral change<sup>66</sup>. Therefore if a behavior must change for reduction to occur, assessment of the behavior must be made to determine behavior change. Self-efficacy of balance might provide viable information about an individual's balance behavior and serve as a method of measuring behavioral change.

It is unknown if a relationship exists between balance self-efficacy and objective clinic and laboratory measures of balance in the healthy, active population. While there is a direct positive relationship between self-efficacy of balance and measures of balance in the balance deficient populations (post-stroke, and elderly), this relationship has not been explored in the young, active



population who are at a high risk of sustaining a lower extremity injury<sup>61</sup> who perform more complex tasks during sports participation (for example, high school basketball players). Presently there is no psychological screening component when examining risk factors for lower extremity injuries. A patient-oriented measure of balance confidence is needed to provide a comprehensive perspective of the evidence surrounding risk of lower extremity injury.

## STATEMENT OF THE PURPOSE

The purpose of this dissertation is to develop an instrument that measures self-efficacy of balance in a young active population employing a series of three studies. The purpose of the first study is to develop a self-efficacy of balance instrument and test the validity of the instrument. The purpose of the second study is to assess stability and reliability of the self-efficacy of balance instrument. Finally the purpose of the third study is to investigate the responsiveness of the Self-Efficacy of Balance Scale (SEBS) over the course of a 15-week season in a sample of female high school basketball players who participate in a lower extremity injury prevention program compared to players that do not participate in an injury prevention program. An additional purpose is to investigate the relationship between self-efficacy of balance and self-reported measures of lower extremity function and objective measures of balance.

## SIGNIFICANCE

The results of these studies will provide researchers and clinicians with a psychometrically sound instrument that captures self-efficacy of balance information in the young, active population. Once developed the SEBS will afford the ability to quantify a psychological component of balance related behavior. Quantifiable balance related behavior would allow integration of knowledge from behavioral science into injury prevention research. Utilization of the SEBS may expose the relationship between both self-efficacy of balance and self-reported

measures of function and objective clinical and laboratory measures of balance, which currently has not been identified in the young, active population.

The SEBS attempts to satisfy the current gap in the literature of psychological influences on balance and risk of injury in the injury prevention literature. Significant contributing factors to lower extremity injury might be revealed with longitudinal testing of the SEBS. Ultimately, the SEBS or SEBS based research may lead to the creation of an efficient and inexpensive screening tool that may aid in the prevention of injury from a behavioral perspective. Furthermore, future research may also lead to the creation of prophylactic interventions designed to prevent injury based on a SEBS or SEBS like screening process.

## RESEARCH HYPOTHESES

Based on a literature review of self-efficacy, lower extremity injuries and risk factors and lower extremity injury prevention, these are the hypotheses for the present studies:

Specific Aim 1: To develop the Self-Efficacy of Balance Scale (SEBS) and determine the face, content, construct, and convergent validity of the instrument.

Hypothesis for Specific Aim 1: Based on a developed scale that measures balance confidence in an older population; items can be developed to address individuals who are younger and more active. The SEBS will have good face validity as indicated by a panel of experts. The SEBS will have good content validity when assessed by an expert panel using Content Validity Ratio<sup>67</sup>. Construct validity will demonstrate that a one-factor model will fit items on the SEBS. Convergent validity will demonstrate a direct positive relationship between the SEBS and self-report lower extremity function as measured by the Foot and Ankle Ability Measure Sport (FAAM-S) subscale and Knee injury and Osteoarthritis Outcome Sport (KOOS-S) subscale.

Approach 1: The scale will be developed based on a spectrum of activities that require balance and occur in daily living or during athletic participation. Experts in

lower extremity injury and self-efficacy will assess the items for face and content validity as well as suggest additional items, change to a current item, or the removal of an item. The scale will then be compared to both an ankle and a knee function scale for construct and convergent validity.

Specific Aim 2: To determine the reliability and stability of the SEBS using a sample of female high school basketball players.

Hypothesis for Specific Aim 2: The SEBS will be reliable when tested for internal consistency (Cronbach's  $\alpha \geq 0.9$ ), as well as over time, with a test-retest method (Spearman's correlation coefficient  $\geq 0.8$ ).

Approach 2: The SEBS will be administered to participants on day 1, and the SEBS will be administered again at day 7 and day 14. Reliability will be evaluated through correlation of scores from test day 1 to test day 7, day 1 to test day 14, and day 7 to test day 14. Internal consistency will be evaluated utilizing scores from test day 1.

Specific Aim 3: Investigate the responsiveness of the SEBS over the course of a 15-week season using a sample of female high school basketball players who participate in a lower extremity injury prevention program compared to players that do not participate in an injury prevention program.

3a) Examine the relationship between the SEBS and self-report measures of lower extremity function as indicated by the FAAM-S and KOOS-S scores

3b) Examine the relationship between the SEBS and objective clinical and laboratory measures of balance as measured by the Balance Error Scoring System (BESS) and Time to Boundary (TTB) measures of postural control respectively.

Hypothesis for Specific Aim 3: The SEBS will be responsive to change, if a change occurs in self-reported lower extremity function, or objective measures of balance. Following the 15-week, evidence-based lower extremity injury prevention program intervention, participants will increase self-efficacy of balance

as indicated by SEBS scores compared to those who do not participate in an injury prevention program.

3a) There will be a direct positive relationship between self-efficacy of balance and self-report measures of lower extremity function as measured by the FAAM-S and KOOS-S.

3b) There will be a direct positive relationship between self-efficacy of balance and objective clinical and laboratory measures of balance as measured by the BESS and TTB measures of postural control.

Approach 3: Participants will be pre and post-tested using the SEBS, FAAM-S, KOOS-S, BESS, and TTB. Participants on the intervention teams will take part in an evidence-based lower extremity injury prevention program, and the control teams will participate in normal basketball activities. Pre-testing scores will be compared to post-testing scores for all participants. Groups (control vs. intervention) will also be compared at post-testing. Correlation analysis will be conducted to reveal the relationship between the SEBS and measures of lower extremity function as well as the relationship between the SEBS and objective measures of balance.

## ASSUMPTIONS

- The participants will understand all patient reported outcomes (SEBS, FAAM-S, KOOS-S) and will provide answers that reflect their functional capacity and balance capability to the best of their ability.
- The participants will feel comfortable and be truthful when answering questions about how they feel about their ability to balance.
- The participants will try their best during balance tests.

## DELIMITATIONS

- The participant population will consist primarily of female high school basketball players. This will limit the generalizability of the results of these studies to female high school basketball players.

- There is rater error associated with techniques of measuring balance using the BESS.
  - The same rater will score the majority of BESS trials to reduce rater error.
- A high school coach will supervise performance of the injury prevention program and log compliance.
- Testing sessions will be in a team setting. Therefore participants may be waiting to be tested. This might be a distraction to participants that are being tested.
  - To control for distractions by teammates, investigators will monitor testing sessions.

## OPERATIONAL DEFINITIONS

Construct validity: The extent to which a scale correlates with another measure that has similar constructs.

Content validity: A judgment if the samples within an instrument are relevant to the content domains.

Convergent validity: How closely an instrument relates to other measures of the same construct to which it should be related.

Item: A single statement or question.

Internal consistency: A test of reliability based on one administration of the measure to determine if items within a scale address the same underlying construct.

PCL model: A contextual model of Patient-, Clinician-, and Laboratory-oriented evidence.

Responsiveness: The ability of a measure to detect change when a change actually occurred.

Static Postural Control: Maintaining center of mass of the body within a particular base of support while attempting to limit movement.

Time-to-boundary (TTB): A spatiotemporal analysis of center of pressure data derived from a force plate. Time to boundary employs the boundaries of the foot, and calculates the velocity of center of pressure excursion and position of the foot at the site of the excursion. TTB measures represent the theoretical time it would take the center of pressure of the foot to reach a border of support (M/L or A/P) if it continued on the same course without a change in velocity.

## Chapter 2: Review of the Literature

### INTRODUCTION

The purpose of this literature review is to: 1) describe self-efficacy and its relationship to social cognitive theory, 2) discuss current evidence in self-efficacy, balance, and injury, 3) discuss the research regarding development of self-efficacy scales, 4) discuss the research regarding lower extremity injury prevention programs and the relationship with self-efficacy and 5) discuss current self-reported measures of lower extremity function and objective clinical and laboratory measures of balance.

### SELF-EFFICACY

Social cognitive theory (SCT), developed by Albert Bandura, posits that cognitive processes serve as emergent activities for human behavior<sup>68</sup>. These evolving activities interact and influence as determinative functions.<sup>69, 70</sup> The interactions of three major factors serve as the structure of SCT. Influencing factors are categorized into: 1) personal factors in the form of cognition, affect, and biological events, 2) behavioral patterns, and 3) environmental events.<sup>38-40</sup> This model of dynamic interaction is referred to as triadic reciprocal causation. Any of the three factors within this model has the ability to influence either or both of the other two factors for behavioral change. The cognitive structure of this model determines what information will be observed, interpreted, and organized to influence change in behaviors<sup>38</sup>. Within SCT, people are “agentic operators” in their life. The foundational assumption of SCT is that individuals have the ability to contribute to their own motivation and action.<sup>37-39</sup>

Self-efficacy is said to influence how well one can organize cognitive, social, and behavioral skills to complete specific tasks or perform in a specific situation and is at the core of SCT.<sup>71</sup> According to SCT, self-efficacy determine the actions and choices that people make. Perceived self-efficacy can effect an individual’s behavior, cognitive process, and affective arousal given a specific task.<sup>72</sup> Human functioning is directly affected by perceived efficacy through behavior, but is also indirectly affected through goals, outcome expectations, perceptions of impediments, and social opportunities within an environment.<sup>71, 73</sup>

The amount of self-efficacy an individual has can determine the amount of effort and persistence one will expend to complete a given task as well as perseverance to overcome any obstacles he or she might face in completing the task.<sup>40-43</sup> The stronger the self-efficacy, the more robust the efforts put forth, and the more likely the task will be accomplished.

Four sources of information can shape personal efficacy. Performance accomplishments or enactive mastery, vicarious experience, social or verbal persuasion, and emotional and physiological states can influence self-efficacy.<sup>40</sup> The influence each source of information imparts on self-efficacy will vary based on how the influence is applied. One source of information acquisition might benefit an individual more than an alternative source of information. Additionally, acquisition of information does not always lead to raising self-efficacy. Negative influence serves to reduce self-efficacy.

Performance accomplishments are considered particularly influential in developing self-efficacy as they are based on past experiences. If an individual has repeated success and limited failure, efficacy will increase, as will drive to overcome future failure or obstacles.<sup>43</sup> The cumulative experiences of accomplishments relating to one behavior, task, or situation is known as mastery experience.<sup>74</sup> Once self-efficacy has improved, the generality of expectation increases as well as coping mechanisms for failures generalize to other situations.<sup>72</sup> Forms of performance accomplishments can be acquired through participant modeling, performance, desensitization (overcoming any fear involved with the particular performance), performance exposure, and self-instructed performance.

Performance modeling can create expectations for success in observers, and thus enhance their efficacy through vicarious experience.<sup>75</sup> The thought is that if an individual sees others successfully perform a task, it will improve an individual's belief that he or she is able to perform the task. Performance of a task or skill is likely to provide a greater source of efficacy than performance modeling.<sup>40, 43</sup> This source of information acquisition is not as dependable as the knowledge attained from the individual's actual task performance and



accomplishments, but influences the cognitive model by observing strategies for correct behavior. Acquiring knowledge through vicarious experiences does not let the observer experience his or her own judgments in performing the task. This leads to less information regarding the development of acquisition of coping skills. Additionally, if an individual does not recognize himself or herself to be as capable or adept as the model performing the task, efficacy might not be enhanced.<sup>40</sup> Viewing successful performances of a task achieved by a variety of people increases self-efficacy beliefs. When multiple types of people are able to successfully perform a task, chances are greater that an individual can relate to someone who accomplished a task. Viewing only one individual accomplishing the task narrows the chances that an individual will be able to relate to the model.

Encouragement and suggesting an individual's capability of achieving a task is considered to be social or verbal persuasion.<sup>40</sup> Verbal persuasion, or an exhortative source of information, aids in accomplishing a task by increasing effort through persuasion in an individual.<sup>40</sup> Social persuasion is a means of further strengthening an individual's beliefs that he or she possesses capabilities to accomplish a task. Positive social assessments have their greatest impact when tasks are well defined as well as the task at hand is reasonable in ability to complete. Successive tasks, starting with simple tasks and building to more complex tasks, can be outlined to increase self-efficacy. Once one simple task is accomplished the next task can build upon the first task and increase in difficulty. As each task is successfully performed, efficacy will increase.

Anxiety and negative emotive arousal can greatly affect self-efficacy beliefs through decline in coping mechanisms and decreased success.<sup>40</sup> Emotional arousals can arrive with fear of performance or fear of the task. When an individual does not fear a situation, there is greater chance of success. Those with minimal fear may be able to control the emotional arousal and reduce any doubts to successfully perform the task. With every successful performance, fears will be reduced and self-efficacy beliefs will increase.

Combining the positive influences of the four sources of information provides the principal medium for developing efficacy.<sup>72</sup> Mastery modeling creates

the necessary skills and a strong sense of personal efficacy to execute a task well.<sup>72</sup> It is the product of the strong influence of performance mastery experiences, modeling of effective coping strategies for a variety of circumstances, inducing physiological capability, and repeated confirmation of coping mechanisms that develops a strong sense of efficacy.<sup>41, 72</sup>

No matter the activity domain, whether an academic setting or in a health behavioral context, the same determinants of knowledge, perceived self-efficacy, and outcome expectations as well as perceived facilitators/impediments influence how and if an individual will adopt particular behaviors.<sup>76-78</sup> The main tenets of social cognitive theory and self-efficacy theory hold true to influence behavior and determine the choices individuals make as well as the efforts, persistence, and perseverance displayed.

#### CURRENT EVIDENCE IN SELF-EFFICACY RELATED TO BALANCE AND INJURY PREVENTION

Recently, the influence of injury on self-efficacy has been explored in athletes who have sustained anterior cruciate ligament (ACL) injuries.<sup>47, 48</sup> A knee self-efficacy scale (K-SES) was created to evaluate individuals' perceived self-efficacy of knee function in patients who had sustained an ACL injury.<sup>49</sup> Patients' preoperative self-efficacy of knee function predicted post surgical self-reported and objective outcomes of knee function.<sup>48</sup> Individuals with high levels of knee function self-efficacy had better outcomes than those with lower levels of knee function self-efficacy one year after surgery. While this model is important in regards to identifying individuals that might have better outcomes following surgery, the information does not help to identify those at risk for a knee injury. The relationship between self-efficacy and outcomes following injury exists; however, it remains to be seen if self-efficacy can be utilized to help predict injury in individuals that are at a higher risk of injury, before an injury occurs.

Evidence of the relationship between self-efficacy, balance, and injury prevention exists in the falls and fear of falling literature within the elderly population,<sup>51-54</sup> the knee osteoarthritis population,<sup>55</sup> as well as the post-stroke

population.<sup>56</sup> A consistent direct, positive relationship between self-efficacy of balance and risk of injury has been established. While this relationship is consistent in the balance deficient population, there is a paucity of information regarding self-efficacy of balance in the young, active, population.

Self-efficacy related to fear of falling is considered to be an individual's belief in their ability to engage in activities of daily living without falling or losing balance. The relationship between cognitive, behavioral, and physiological factors determine fear of falling.<sup>53</sup> Fear of falling is significantly mediated by fall-related self-efficacy, but is not one in the same.<sup>52</sup> Falls self-efficacy has a direct relationship between functional balance and physical function<sup>52</sup> in the older population. This relationship has theoretical significance in that falls self-efficacy has direct influence on functional outcomes. A direct relationship between balance and cognition has also been established.<sup>56</sup> Regardless of the population, individuals with cognitive deficits tend to have decreased postural control compared to individuals without cognitive impairments.<sup>56, 57, 59, 60, 79</sup>

Falls self-efficacy was used to measure the effect of a Tai Chi intervention as well as produces effects on the participants' fear-of-falling outcome.<sup>54</sup> This method of studying self-efficacy was conducted to identify underlying mechanisms about how the intervention, in this study Tai Chi, achieved its effects. A change was seen in the mediating variable of falls self-efficacy over time in participants in the Tai Chi intervention, compared to the control-stretching group. Additionally, it was observed that of the individuals who had the greatest reduction in fear of falling were in the intervention group, who also had increased falls self-efficacy. Older adults who participated in a 6-month Tai Chi program improved falls self-efficacy, and likely reduced fear of falling through increased falls self-efficacy gained from the physical activity intervention.<sup>51</sup> This study gives evidence to the fact that falls self-efficacy can be increased by physical activity that is focused on balance and physical function,<sup>54</sup> as well as reduce fear of falling in an older population.

Objective measures, such as the Berg Balance Scale<sup>52, 53</sup> and center of pressure (COP) measures,<sup>57, 80, 81</sup> as well as subjective measure, such as the

Activities-specific Balance Confidence (ABC) scale<sup>51, 56</sup> are current methods used to assess balance in the older population. The specific balance measure of COP has been used to evaluate the global function of the sensorimotor system<sup>81</sup> in the young active population as well as the older population. The scores of these balance tests are then correlated with scores obtained through efficacy scales (balance self-efficacy and falls self-efficacy) to determine if there is a relationship between the COP (representing balance) and balance related self-efficacy.

Research has revealed that low balance self-efficacy, a term often used interchangeably with fear of falling, is related to poor balance, increased fall risk, restriction of activity, loss of independence and reduced quality of life in the balance deficient population.<sup>57, 59, 60</sup> The relationship between balance measures and self-efficacy has been established for certain populations with postural control deficits. A relationship between increased balance performance difficulty and decreased self-efficacy has also been demonstrated in a healthy population when faced with height-induced postural threats.<sup>80</sup> Challenging balance tasks that pose a postural threat, such as a height-induced balance task, decreased balance self-efficacy in 31 healthy young adults. Representative of the cognitive influence of balance, perceived balance can be manipulated regardless of change in efficacy or balance.<sup>82</sup>

Psychological indicators of balance confidence are important to measure in conjunction with balance test performance to establish the relationship between the two constructs in the young, active population.<sup>57</sup> Research suggests that injury reduction is not feasible without some kind of behavioral change.<sup>66</sup> Therefore if a behavior must change for reduction to occur, the behavior must be assessed to indicate if a change actually occurred. Self-efficacy of balance might provide viable information about an individual's balance behavior and serve as a method of measuring behavioral change. Presently there is no psychological component when examining risk factors for lower extremity injuries. It is unknown if a relationship exists between balance self-efficacy and objective clinic and laboratory measures of balance in the healthy, active population.

## MEASUREMENT OF SELF-EFFICACY

Currently, several balance self-efficacy scales exist, however the instruments are targeting elderly or post-stroke individuals who have a low level of function and are at a high risk of falling.<sup>57, 60, 83</sup> The Activities-specific Balance Confidence (ABC) Scale<sup>64</sup> measures the construct of perceived balance ability (an individual's level of confidence in the ability to maintain balance during daily activities). Many studies have utilized this measure, and consider it to be a valid, reliable measure of balance self-efficacy in the older population (age  $\geq 65$  years).<sup>57, 60, 84</sup> The ABC scale has demonstrated to be a useful tool in this older population, but likely not sensitive enough for the young, active population. The foundation of this instrument is important for developing a new self-efficacy of balance scale targeting the young, active, population.

Certain criteria have been established for construction of a psychometric instrument, specifically a self-efficacy scale. A well-constructed self-efficacy scale contains items that are clear, have contextual meaning, have a direct impact on the individual, and evaluate different levels of the domain.<sup>33, 73</sup> Creating a self-efficacy scale that will have predictive and explanatory value requires much attention. Items contained within the scale must be developed carefully and attempt to eliminate as much bias as possible. The scale must also be specific to the self-efficacy belief that is being explored (in this case balance). A guide to constructing sound self-efficacy scales was developed by Albert Bandura.<sup>71, 73</sup> Recommendations of domain specificity, progressions of challenges, content relevance, scaling, phrasing, bias reduction and validation were the focus of the guide.<sup>34, 71, 73</sup>

In order to create a self-efficacy scale that will be precise, accurate, reliable, and valid, it is important that items within the scale have a significant impact on human functioning within the activity domain.<sup>71, 73</sup> Items that address qualities and characteristics of behaviors specific to the activity domain are important to provide appropriate context. If the items within the scale do not have direct impact, or provide insights into self-regulatory behavior, the scale will not be effective in predicting or explaining the efficacy belief of interest. To make

sure that items have influence on the given efficacy belief, knowledge of what it takes to succeed in the given domain is necessary.<sup>71</sup> In addition to knowing what it takes to succeed, it is equally important to be clear about what constitutes a successful performance. Ambiguity or measures of efficacy with no context within the scale will decrease its effectiveness to explain or predict performance behavior.<sup>71</sup>

Efficacy beliefs vary in level, strength, and generality.<sup>71</sup> Beliefs of efficacy will vary according to the significance of the task, complexity of the task, and domain of functioning. Items depicting different levels of task demands should be included into the scale to assess efficacy strength. Strength of efficacy is rated in terms of a person's belief in their ability to execute essential activities of the skill. It is postulated that if the activity is too easy, everyone will be efficacious and there will be no room for improvement or discrimination between individuals with different strength of efficacy regarding higher levels of situational demand.<sup>73</sup>

Scales can be composed of single or dual judgment of capabilities. In the dual judgment format, capability of performance of the skill is assessed by a 'yes' or 'no' answer. If the response is yes, a rating of strength of skill performance is then documented. In the single judgment format, strength of efficacy is rated for a given skill. If the respondent does not have any belief that he or she possesses capability to perform the skill, the strength rating would be a "0" on an efficacy strength scale of 0 to 100 in increments of 10. Scales with a single judgment format is the preferred method of assessing self-efficacy. Items should be phrased in terms of "can do" to assess judgment of capability and not intention. Additionally, it was found that employing an 11-point scale as the method for assessing capability produces better predictive ability than a 5-interval scale.<sup>73</sup> The necessity for an 11-point scale is considered valid for pre- and post-testing, but might not be necessary for predictive scales where a 5-point scale would be sufficient.

Self-efficacy scales should have face validity, or appear to measure what the scale is intended to measure. The scale should measure the perceived capability of what it claims to measure.<sup>73</sup> Construct validity should also be tested

through hypothesis testing, comparing high versus low scores. The theory that is being tested should be the distinguishing factor between high and low scorers. Pretesting the items in the scale will help determine face validity as well as construct validity, as a means of item analysis. Pretesting will reveal questions that might be ambiguous or unclear. If multiple people are reporting the same score on one particular item, this item might not have the ability to differentiate between respondents.<sup>73</sup>

## LOWER EXTREMITY INJURY PREVENTION PROGRAMS AND SELF-EFFICACY

Researchers estimated that emergency departments treat 4.3 million sports (including recreational) related injuries each year,<sup>85</sup> with high school athletes accounting for an estimated 2 million injuries, 500,000 doctor visits, and 30,000 hospitalizations per year.<sup>83</sup> Lower extremity injuries are the most common sports-related injury, with ankle injuries accounting for 40%, knee 25%, and thigh 14% being the most frequent.<sup>61</sup> More than 550,000 boys and 429,000 girls participated in intramural high school basketball teams during the 2009-2010 academic school year.<sup>86</sup> According to injury tracking data, basketball players have the second highest lower extremity injury rate for males and females.<sup>61</sup>

An average of 375,350 basketball-related injuries were treated in US emergency departments per year between 1997 through 2007.<sup>62</sup> There is a major focus to reduce the number of injuries that occur in high school basketball. Injury prevention programs have materialized in the realm of sports medicine to reduce or minimize specific risk factors for injury. The development of injury prevention programs, using evidence-based practice, suggests that scientific evidence, found in the literature, as well as clinical expertise assess the needs of the client/patients and address those needs within the program.<sup>87</sup> Exercises, progression, duration, and population are all important factors to assess when creating an injury prevention program utilizing evidence-based practice. Additionally, knowledge of modifiable risk factors by exercise is important when creating an effective, evidence-based program.

In a systematic review of the effects of balance training on neuromuscular control and performance enhancement by Zech and colleagues,<sup>2</sup> 327 of the 787 subjects were athletes, with the other groups consisting of recreationally active (n= 153) and healthy non-athletes (n= 307) with the a mean age ranging from 14.5 to 31.7 years. The mean ages in studies including athletes ranged from 14.5 to 21.5 years of age. Overall, athletes were younger than the other two groups.<sup>2</sup> It must be recognized that athletes will likely have a higher level of performance before the intervention is employed; therefore it is difficult to generalize results of studies that use non-athletes to athletes. When comparing athletes and recreationally active individuals to non-athletes, Zech et al<sup>2</sup> found that balance training increased postural sway and function balance. Healthy trained subjects increased postural sway when compared to healthy un-trained controls, and controls that participated in a weight-lifting program.<sup>2</sup> In regards to increasing strength, the balance training intervention did not increase strength or jumping performance of the athlete or recreationally active groups, but did have significant effects on knee muscle strength in untrained healthy subjects. Female athletes are reportedly 4 to 6 times more likely to sustain a non-contact anterior cruciate ligament (ACL) injury than their male counterparts.<sup>88, 89</sup> Therefore, when studying the effectiveness of an injury prevention program, it is logical that female athletes, particularly soccer athletes, would be utilized as participants.

Particular risk factors for lower extremity injury have been identified through numerous studies. Specifically for ACL injury, several modifiable risk factors as well as risk factors that cannot be modified, such as gender and anatomy, have been identified. In females, it seems that decreased neuromuscular control of the trunk,<sup>3, 15, 25</sup> increased valgus and knee abduction motion and torque during landing,<sup>10, 28, 90, 91</sup> and neuromuscular imbalance<sup>92, 93</sup> or poor neuromuscular control<sup>24, 28, 94</sup> of thigh and hip musculature are risk factors for ACL injury. Balance, measured by postural sway, has been shown to predict ankle sprains in high school basketball players.<sup>22, 95</sup> Additionally, decreased balance has been demonstrated as a risk factor in soccer players.<sup>20, 96</sup> Increased measures of balance have been shown to reduce risk of injury in those who have



never had an ankle sprain, which is the primary risk factor for sustaining an ankle sprain<sup>97</sup> as well as for those who had a history of previous ankle sprains.<sup>27</sup>

The duration of an injury prevention program can influence the effectiveness of modifying risk factors, or reducing injuries. Duration, frequency, and dosage of injury prevention programs vary widely throughout the literature. Injury prevention programs published recently to either reduce knee or ankle injuries have ranged from 4 weeks up to full sports seasons. The most frequent program length was 6 weeks<sup>5, 6, 10, 16, 20, 93, 98, 99</sup> in a search of the literature, while a 4 week intervention program was the most frequent duration found by Zech et al.<sup>2</sup> Another aspect to consider is how frequent each session is performed per week, as well as the time spent in each session performing the intervention program. Most commonly, training sessions were conducted 3-4 times per week. The time spent performing the prevention program was anywhere from 10 minutes a session<sup>97</sup> up to 90 minutes per session.<sup>16</sup> Training programs that were longer than 4 weeks demonstrated improved balance after 6, 10, and 12 weeks of balance training with greater effect sizes in favor of increased postural sway and single-leg stance time compared to studies only lasting 4 weeks. Specifically changes in postural sway, as well as in results of the Star Excursion Balance Test (SEBT) and single-leg stance time on unstable surfaces were demonstrated following intervention programs 6 weeks and longer.<sup>2</sup> A meta-analysis investigating neuromuscular interventions aimed at ACL injury preventions by Hewett et al<sup>1</sup> recommend for the prevention of ACL injuries, the duration of the training program should be a minimum of 6 weeks in length, and training sessions should be performed more than one time per week. Studies that were shown to reduce odds ratios (ORs) of experiencing an ACL injury were 6 weeks or greater in length<sup>1</sup>. While interventions trended toward significance, all ORs except Mandelbaum et al<sup>13</sup> crossed 1, indicating no true reduction in odds in those that participated in the injury prevention program. The overall effect of all injury preventions, according to Hewett et al<sup>1</sup>, were significant resulting in an OR of 0.40 (0.26, 0.61) in favor of training. In summary, an injury prevention program intending to reduce ACL injuries or increase performance and

neuromuscular control should be at least 6 weeks in length, and have a frequency of 3-4 times per week.

As has previously been discussed, training programs that include balance exercises, are often implemented with the goal of enhancing performance and preventing injury.<sup>2</sup> Effectiveness of balance training in prevention of injury, or reduction in risk of injury risk has been investigated,<sup>2, 11, 13, 27, 100, 101</sup> but evaluation of psychological and cognitive factors have not been included in these prospective investigations. The relationship between cognitive and self-referent factors and motor performance has gained some attention in the realm of athletic performance.<sup>102</sup> Positive self-beliefs of physical capabilities have shown to improve perceptual-motor skills.<sup>102</sup> Psychological indicators of balance confidence are important to measure in conjunction with balance test performance to establish the relationship between the two constructs.<sup>57</sup> Assessment of these factors is necessary to examine how psychological measures affect performance on tests used in clinical balance assessments.<sup>80</sup> If we are able to reach information from the cognitive aspect of function through self-efficacy, manipulations of the self-efficacy construct can be attained and balance measures might improve, reducing risk of injury.

It has been demonstrated that self-efficacy can be manipulated through physical activity in healthy college students.<sup>103</sup> Following a strength-training intervention, self-efficacy beliefs increased in an exercise group when compared to a control group. It is therefore hypothesized that an intervention aimed at increasing postural control and balance, will lead to increased self-efficacy related to balance. Balance exercises will progress in difficulty throughout the intervention to better develop self-efficacy by building efficacy throughout the intervention. The intervention will utilize tasks that are uncomplicated during the first few weeks of the program, progressing to tasks that are increasing in difficulty. Accomplishments of the uncomplicated balance tasks will build self-efficacy by multiple performance accomplishments. Higher self-efficacy will lead to increased motivation and effort to tackle more difficult balance tasks.<sup>40-43</sup> Increased self-efficacy related to balance would theoretically influence postural

control. Improvement in balance and postural control will reduce risk of injury to the lower extremity.

## SELF-REPORTED MEASURE OF LOWER EXTREMITY FUNCTION AND OBJECTIVE CLINICAL AND LABORATORY MEASURES OF BALANCE

Several patient-oriented measures are utilized when evaluating an athlete's health status, and ability of the lower extremity. Emphasis is placed on the patient or athlete's perception of their overall health, and the health or capability of their knees and ankles. The Medical Outcomes Study Short Form Health Survey (SF-36) centers on the athlete's estimation of his or her functioning, well-being, and overall health and is considered a measure of HRQOL.<sup>104</sup> The Knee Injury and Osteoarthritis Outcome Score (KOOS) assess pain, symptoms, activities of daily living, sport and recreation function, and knee-related quality of life.<sup>105</sup> The Foot and Ankle Ability Measure (FAAM) is a self-reported outcome that measures physical function for individuals with leg, ankle and foot musculoskeletal disorders.<sup>106</sup> These three self-report instruments provide the athletes' perspective of their health status and physical functioning. Within the ICF model, the SF-36, KOOS, and FAAM provide information within the activities and participation domains, and do not focus as much on the bodily structures and functions domain.

The SF-36 is a generic self-report questionnaire that provides information about how the athlete perceives his or her physical and mental wellbeing. The whole of the SF-36 is comprised of 8 components: physical function, role physical, bodily pain, general health, and two summary scores (physical component summary scale and mental component summary scale) which determine the physical and mental status of athletes (see Figure 2).<sup>104</sup> The SF-36 is a 36-item questionnaire with Likert-style questions. Each of the 8 components can range in scores from 0 to 100, the higher the score, the better the HRQOL. The SF-36 was originally shown to be valid and reliable in the general population<sup>107</sup> and normative scores of 18-24 year-old men and women have been published to utilize as normative data, or a reference group. Division I (DI)

athletes scores on the SF-36 were compared to those of the reference group, and it was shown that DI athlete, non-injured males had an increased role emotional scores when compared to the normative data.<sup>104</sup> Non-injured female athletes had higher mental component summary, physical function, role emotional, mental health, and vitality scores when compared to the normative group.<sup>104</sup> In a study comparing HRQOL in adolescent athletes and non-athletes, athletes reported higher scores on the physical function, general health, social functioning, and mental health components as well as the mental health composite score, but lower on the bodily pain component than nonathletes.<sup>108</sup> The SF-36, a generic self-report scale, provides vital information concerning the athletes perspective on his or her wellbeing, but it is important to realize when analyzing and comparing scores to reference groups, athletes, adolescent and DI, might have different normative scores than their non-athlete peers.

The KOOS is a self-report outcome that measures five outcomes: pain, symptoms, activities of daily living, sport and recreation function, and knee-related quality of life.<sup>105</sup> Unlike the SF-36, which is a generic measure of HRQOL, the KOOS is measuring HRQOL specific to the knee. The KOOS has been demonstrated valid and reliable, as well as responsive to change. The KOOS was also validated in an athletic population, and was shown to be reliable, had high construct validity, and responsiveness when compared to other knee outcome scales as well as the SF-36.<sup>109</sup> The KOOS is a 42 item with Likert-style questions, in the 5 aforementioned categories that can each be scored separately.<sup>105</sup> The Sport and recreation function and knee-related quality of life are two subscales that are more specific to the athletic population, and can be utilized separately resulting in scores that can stand-alone. The benefit of utilizing specific sections of the KOOS is that the other sections, such as the activities of daily living that might not be as specific, nor telling within the athletic population, might not need to be scored.<sup>105</sup>

The FAAM is a self-reported evaluative instrument that comprehensively assesses physical function of the leg, ankle, and foot.<sup>106</sup> The FAAM contains two

subscales, the FAAM activities of daily living (ADL) subscale and Sports subscale. Each has been shown to be valid, reliable and responsive to change in a population with previous leg, foot or ankle musculoskeletal disorders.<sup>106</sup> The FAAM has also demonstrated reliability and ability to detect functional deficits in patients with chronic ankle instability.<sup>110</sup> Similar to the KOOS, the FAAM Sports subscale can be administered as a stand-alone measure, and its items are more specific to athletes, and recreationally active individuals.<sup>106</sup>

Primarily, two clinician-based measures are utilized in studies investigating injury prevention and risk reduction in the lower extremity, the balance error scoring system (BESS)<sup>111</sup> and the Star Excursion Balance Test (SEBT).<sup>112, 113</sup> Both clinical tests measure postural control, are easy to administer and perform clinically, and do not require much equipment or space. Tests such as the BESS and SEBT provide clinicians with tools for decision-making, whether it might be return to play criteria, or progression within a rehabilitation program, as well as an objective outcome that can be tracked over time.

The BESS is an objective tool for clinical assessment of postural control.<sup>111</sup> The traditional BESS utilizes 3 stances (double limb, tandem stance, or single-limb) on two surfaces (firm and foam) with the eyes closed. The score is derived from the tester counting the amount of errors that the subject makes within each 20-second trial. An error is considered to be an athlete lifting hands off the iliac crests, opening the eyes, stepping, stumbling, or falling, remaining out of the test position for more than 5 seconds, moving hip into more than 30° of flexion or abduction, or lifting forefoot or heel.<sup>111</sup> The BESS has demonstrated excellent intratester reliability, meaning that it can be scored accurately<sup>114</sup>, and good reliability when compared with forceplate measures of postural sway.<sup>111</sup> A modified version of the BESS utilizes just two stances (single-limb and tandem stance) and two surfaces.<sup>115</sup> The four conditions are tested for 20 seconds three times each. The modified version of the BESS was found to be valid and reliable and found that by removing the double-limb stance the duration of the test decreased, and there was an increase in the interclass reliability coefficient of the BESS.<sup>115</sup> When used to assess the effects of a 6-week neuromuscular training

program, the BESS demonstrated sensitivity to change. It was sensitive enough to detect change from baseline measures to post-testing measures.<sup>116</sup>

The SEBT is another test of postural control, but assess dynamic balance<sup>112</sup>, where the BESS is more a test of static balance. The goal of the SEBT is to balance on one limb, while performing a maximal reach with the other limb in one of three directions (anterior, posteriorlateral, posteriomedial)<sup>117, 118</sup>. The maximal reach is recorded for three trials, in each direction after 4 practice trials, and the distance of the reach is normalized to limb length. The maximal reach distance for each direction is summed to form a composite reach distance to represent overall performance of the test. A trial may be discarded if the athlete failed to maintain unilateral stance, lifted or moved the stance foot, touched down with the reach foot, or failed to return to the starting position with the reach foot.<sup>112</sup> Reliability of the test has been reported as good for all directions of the test.<sup>112</sup> The SEBT was used to predict lower extremity injuries in high school basketball players.<sup>117</sup> High school basketball players with greater anterior right/left reach distance difference, and girls with a decreased normalized composite reach distance were more likely to suffer a lower extremity injury.<sup>117</sup> The SEBT was able to predict injury in high school basketball players, and was also able to detect differences in dynamic balance from pre to post-test measures following a neuromuscular training program.<sup>11, 95, 116</sup> Additionally the SEBT has also been used to identify individuals with chronic ankle instability.<sup>119</sup>

The BESS was chosen as the clinical measure of balance to be utilized throughout these studies primarily because it is only testing balance. The SEBT assess dynamic balance, which includes balance, as well as flexibility as well as strength. To establish a relationship between self-efficacy of balance and clinical measures of balance, the BESS was thought to provide the best method for assessing strictly static balance.

Laboratory-oriented measures tend to focus on equipment intensive, highly sensitive measures that sometimes can be expensive and space intensive, and often far removed from the clinician and the patient. Measures such as postural sway captured by forceplates and 3-dimensional (3D) motion analysis

are two laboratory-oriented measures that researchers often use to capture outcomes that might not be revealed in clinical tests or patient-reported outcomes. By utilizing laboratory-oriented measures, researchers hope to gain information about what is occurring within the postural control system, establish change within neuromuscular control, and note any biomechanical changes that can be contributed to a neuromuscular training program.

Laboratory measures of postural control are often utilized for assessing changes in static or dynamic balance.<sup>8, 14, 16, 20, 97</sup> Center of pressure (COP) measures have been used to assess the global function of the sensorimotor system, measuring changes in balance during single-limb, and double-limb stance, as well as detecting postural control deficits in individuals with chronic ankle instability.<sup>81, 120-122</sup> COP is a composite score for the three dimensional forces that occur within the interaction of the foot and the forceplate.<sup>81</sup> The forceplate measures three ground reaction forces along the medio-lateral, anterior-posterior, and vertical axes.<sup>123</sup> Movement in the COP is determined by normalizing the COP measures to the boundary of the base of support (the foot), and the measures are expressed as a proportion of the length of the support for anterior-posterior (A/P) measures, and the width of support for the medio-lateral (M/L) measures.<sup>123</sup> As the COP moves throughout the course of the balance trial, each COP data point's position and velocity to the next point is calculated and divided by the sampling rate to calculate the instantaneous velocity.<sup>120</sup> Time to boundary (TTB) measures represent the theoretical time it would take the COP to reach a border of support (M/L or A/P) if it continued on the same course without a change in velocity.<sup>81, 120</sup> Ultimately a time series of data points is captured, and the minima (the closest points to the respective boundary of support before a change in direction), the absolute minimum TT, the mean of the minimum, and the standard deviation of the minima are calculated for the M/L and the A/P directions for each trial.<sup>81</sup> Depending on the methods that are warranted for balance assessment COP and TTB measures prove to be valid and reliable measures for assessing postural control.<sup>120, 121, 123</sup>

## Chapter 3: Development of the Self-Efficacy of Balance Scale

### INTRODUCTION

Sports participation has many health benefits, but also comes with risks. Lower extremity injuries are the most common sports related injury. The ankle, knee, and thigh are most prevalent ranking 40%, 25%, and 14% respectively<sup>61</sup>. Females incurred more season-ending lower extremity injuries, and twice as many knee injuries requiring surgery than their male counterparts<sup>61, 63</sup>. Prevention of these lower extremity injuries by means of identification of risk factors is a major focus of clinicians and researchers alike.

To implement any injury prevention plan, it is important to understand the risk factors involved. Risk factors for lower extremity injuries are multifactorial in nature<sup>30</sup>. Biomechanical, neuromuscular, and psychological factors can influence the risk of injury. Poor postural stability and neuromuscular control have been shown to increase the risk of ankle and knee injuries in young, active individuals<sup>22, 24, 25</sup>. Methods have been developed to use as an approach toward screening individuals to assess if an increased risk of lower extremity injury is present. Postural stability and neuromuscular control can be measured clinically as well as with laboratory instruments. The Balance Error Scoring System (BESS)<sup>111</sup> and measures of Time to Boundary (TTB)<sup>120</sup> are two examples of methods to identify individuals with decreased levels of postural and neuromuscular control<sup>121, 124, 125</sup>. Establishing a method for identifying the psychological aspect of risk for ankle or knee injuries will provide information that is currently lacking from lower extremity injury prevention literature.

A psychological component used to identify psychological characteristics of behavior is self-efficacy. Self-efficacy, a self-regulatory mechanism, is defined as an individual's perception of their capabilities to complete specific tasks or perform in a specific situation<sup>36</sup>. Previous research has demonstrated that high physical self-efficacy expectations are positively related to better physical performance in accuracy<sup>46</sup>, endurance<sup>44</sup>, and overall performance outcome<sup>45</sup>. Balance confidence, or self-efficacy of balance, represents a quantifiable psychological component of balance related behavior in the elderly<sup>57</sup>,



osteoarthritis<sup>55</sup>, and post-stroke populations<sup>56, 126</sup> but has not been investigated in the young active population. Self-efficacy of balance would fill part of the psychological assessment void that is currently present in the risk of lower extremity injury research.

The relationship between self-efficacy of balance and balance related behavior is unknown in the young, active population. Investigation of the relationship between balance and self-efficacy might help to further explain the risk of injury in the lower extremity in young active individuals. Self-efficacy of balance will provide unique patient-oriented information to help complete the three domains of evidence (patient, clinical, and laboratory) within this study to provide the best contextual evidence<sup>127</sup>. It is important to investigate this psychological component of injury prevention to potentially identify those with additional risk factors, particularly in a population at a high risk of injury<sup>61</sup>.

To effectively measure self-efficacy of balance, it is imperative to utilize a valid reliable instrument. The Activities-specific Balance Confidence (ABC) scale is a commonly used measure that addresses level of balance confidence during activities of daily living in older adults<sup>64</sup>. While this scale addresses balance confidence, it examines everyday tasks, and might not be sensitive enough to assess balance confidence in young, healthy, active individuals. An instrument that is targeted for the young, active population is needed to accurately assess self-efficacy of balance. A valid measure of self-efficacy of balance is needed to determine if a relationship between self-efficacy of balance and objective measures of balance exists. Therefore, the purpose of this study was to develop an instrument to measure the construct of self-efficacy of balance in young, active individuals.

## METHODS

### Research Design

The development and validation of the Self-Efficacy of Balance Scale (SEBS) followed a series of four phases 1) develop items and assess face validity, 2) evaluate content validity, 3) assess construct validity, and 4) establish

convergent validity of the SEBS. These phases were implemented to systematically construct a sound, quality instrument for assessing balance self-efficacy. Throughout the four phases, items had the potential to be flagged for removal from the scale. If an item was flagged on two or more occasions (for low content validity ratios, high skewness or kurtosis, low item-total) it was revised or removed from the scale upon occurrence of the second flag<sup>128</sup>.

#### Phase 1: Item Development and Determination of Face Validity

The purpose of this phase was to develop items that are particular to balance related activities considered fundamental in a young, active population. Additionally, the items that were developed underwent scrutiny by a panel of experts to assess face validity of the Self-Efficacy of Balance Scale (SEBS).

#### Participants

A panel consisting of five athletic trainers (AT) with clinical and research experience, and one expert on self-efficacy, voluntarily participated to assess face validity. The following criteria were used to select the athletic trainers on the panel: certified AT ( $9.2 \pm 5.7$  [range 5-12] years certified), 1) experience in design and conduct of lower extremity research, 2) an advanced degree in kinesiology, rehabilitation sciences, athletic training, and/or 3) clinical experience with exposure to the prevention, recognition and treatment of lower extremity injuries.

#### Procedures

An initial pool of 17 items was created through adaptation of previously published scales that have undergone rigorous testing, to better fit the target population. The items included in the initial pool of the SEBS were adapted from the Activities-specific Balance Confidence (ABC) scale<sup>64</sup> and the Foot and Ankle Ability Measure sports subscale (FAAM-S)<sup>129</sup>. These measures were chosen to represent an established self-efficacy of balance scale (ABC scale), and a commonly used measure self-reported function of the lower extremity (FAAM-S).

The ABC scale is a common measure of balance confidence in the elderly population (> 65 years), and has been demonstrated to be valid and reliable<sup>64</sup>. The ABC scale is not intended for use within the young active population due to the low-level of activities that are used to assess balance confidence, such as every day activities including “sweeping the floor” and “walking around the house”. While these activities are sensitive enough to assess balance self-efficacy for the older and the balance deficient population, young, active individuals will require items that include judgment on more complex tasks that would represent a more active lifestyle, such as running and jumping. The concepts from the ABC scale were modified to fit the younger active population.

The FAAM-S is used to assess physical function for individuals with leg, ankle and foot musculoskeletal disorders<sup>129</sup>. Items within the FAAM-S utilize scenarios that involve complex tasks that the young, active population is more likely to perform and represent more challenging tasks than those in the ABC scale. While the FAAM-S is useful to detect physical dysfunctions of the lower extremity, it does not address any psychological aspects of the individual in the ability to perform functional tasks.

In order to create a self-efficacy scale that will be precise, accurate, comprehensive and valid, it is important that items within the scale have a significant impact on human functioning within a specific activity<sup>71, 73</sup>. Items that address qualities and characteristics of behaviors specific to the particular activity are important to provide appropriate context. The items within the ABC scale were used in conjunction with the FAAM-S to help create good content validity of the SEBS for this particular population. Good face validity indicates that items within a scale are truly measuring what they were designed to measure. Adaptation of items from the FAAM-S and ABC scale, that have already been deemed to have face validity, will help to establish face validity of the SEBS. Efficacy beliefs vary in level, strength, and specificity. It is important to include a range of difficulty in tasks that represent the domain of balance confidence<sup>71</sup>. The items in the SEBS were specifically developed to represent a spectrum of activity

difficulty. Items ranged from low-level activities such as walking, to higher-level activities such as balancing on one leg with the eyes closed.

Items were phrased in terms of “can do” to assess judgment of an individual’s capability in completing a task, and not if an individual “will do” a certain task, which indicates intention<sup>73</sup> (See Appendix A: SEBS Version1.0). The concept of self-efficacy highlights perceived capability, what an individual perceives he or she can achieve or accomplish in a given situation. A judgment of capability, or “can do”, represents the actual ability the individual thinks he or she possesses, while “will do” indicates an act of intention.

To ensure good face validity, items of the SEBS underwent scrutiny from a panel of five experienced athletic trainers and one expert in self-efficacy research. The panel was asked to review the original 17 items for wording, clarity, missing content and face validity, and answer the following questions: 1) Do you believe that the SEBS appears to measure the confidence one has in the ability to balance to perform athletic activities? 2) Do you recommend items should be added, if so what? 3) Do you recommend items should be deleted, if so which ones? 4) Do you recommend revision of any of the current items, if so, what revisions do you suggest? If an item was suggested for deletion, it was flagged for potential removal from the scale.

## Data analysis

Following the panel’s review of the SEBS the original 17-item scale was revised to reflect recommendations, including adding new items. Items on the original scale that addressed unilateral tasks were divided into two items to address both the right and left leg separately. Additionally, changes were made to the wording and clarity of items within the scale as well as scale instructions. No items were flagged for potential removal from the scale.

## Phase 2: Content Validity

The purpose of phase 2 was to adapt the Self-Efficacy of Balance Scale (SEBS) to reflect changes suggested by the panel. Content validity was assessed through expert analysis in the second phase.

## Participants

A second panel of six experienced ATs ( $11.8 \pm 6.7$  [range: 8-22] years certified), volunteered to assess content validity. The second panel did not contain any members from the first panel. The following criteria were used to select the athletic trainers on the panel: certified AT experience in design and conduct of lower extremity research, an advanced degree in kinesiology, rehabilitation sciences, athletic training, and/or clinical experience with exposure to the prevention, recognition and treatment of lower extremity injuries. Before data collection, the objectives were explained, and participants agreed to answer the questions objectively and to the best of their ability.

## Procedures

To assess content validity, the panelists were asked to rate each item on the SEBS version 2.0 (See Appendix B: SEBS Version 2.0) using methods established by Lawshe<sup>67, 130</sup>. Each panelist was instructed to indicate whether each item on the newly constructed scale was 'essential,' 'useful, but not essential,' or 'not necessary' to performance of the construct. Each item should assess balance in situations that are fundamental for a young, active population. The panelists had no contact with one another and did not form any consensus when indicating levels of content.

## Data Analysis

A content validity ratio (CVR) (see Figure 3.1) was used to quantify content validity through the summary of raters' judgments. If the majority of the panel agreed that an item was "essential" this item had some degree of content

validity and a positive CVR<sup>19</sup>. The CVR can range from 1 to -1 for an item. Minimum significant CVR values, based on the number of panelists that rate the items, have been suggested<sup>67</sup>. These values are quite strict, and require a considerable number of panelists. Positive CVR values that are lower in magnitude than the suggested minimum values have been used in previous studies when a small number of panelists are used to provide ratings<sup>130, 131</sup>. The panel reviewed items on the SEBS for level of content. Any item that had a negative CVR, indicating that the majority of panelists did not agree the item was essential, or a CVR of 0, indicating only half of the panel thought the item was essential, was flagged for potential rejection from the scale. The panel also had an opportunity to add items to the scale as well.

Following analysis of the panel's responses, the SEBS was not altered. However five of the items were flagged for potential removal from the scale due to low CVR values. The panel did not suggest any items to be added. The SEBS version 2.0 remained the working instrument for further analysis.

### Phase 3: Construct Validity

The purpose of phase 3 was to examine the underlying constructs of the scale by conducting a factor analysis of responses. The SEBS was theorized to measure the phenomena of balance self-efficacy. The postulated construct of the SEBS is that responses will reveal an individual's perceived capability to balance in situations that are fundamental for a young, active population. Good construct validity will signify that the SEBS actually measures self-efficacy of balance. Means, standard deviations, frequency distributions, skewness, and kurtosis were also evaluated in this phase.

### Participants

Participants in Phase 3 consisted of university undergraduate students who were enrolled in a health science class and female high school basketball athletes during the 2011-2012 season from four Central Kentucky high schools. There were 74 (age= 18.4± 0.7 years) undergraduate students and 57 (age=

15.8± 1.3 years) female high school basketball athletes who agreed to participate in the study. Before the study began, all participants provided written informed consent, and the University of Kentucky Institution Review Board approved the study.

## Procedures

Following consent, each participant was asked to complete the SEBS Version 2.0 containing 21 items assessing an individual's balance confidence in various situations. Each of the 21 items had 11-point Likert response alternatives that ranged from 0 or "not confident" to 10 or "extremely confident". Employing an 11-point scale as the method for assessing capability produces better predictive ability than a 5-point scale<sup>73</sup>.

## Statistical Analysis

Principal component analysis was used to conduct an exploratory factor analysis (EFA) to assess the construct of the SEBS Version 2.0. Through EFA, the underlying constructs of the scale can be objectively isolated without theoretical expectations<sup>132</sup>. Factor analysis is a commonly used statistical method for instrument development to analyze relationships among variables and is recommended for use in self-efficacy scale development<sup>73</sup>. A factor is defined as a combination of test items that are believed to belong together<sup>133</sup>. Identified factors define the construct of the overall SEBS scale. Unrelated items should not be utilized to examine the construct of balance self-efficacy. If an item was considered to be an outlier, or unrelated, it was flagged for potential removal from the scale.

The Kaiser criterion was used to determine the number of factors contained within the SEBS. The Kaiser rule, commonly used, requires components with eigenvalues, the variance in all of the variables that are accounted for by that factor, less than 1.0 to be dropped<sup>134</sup>. Additionally a parsimonious factor model whose meaning is relevant and comprehensible was also taken into consideration. Additional modes of factor assessment were

implemented because while frequently used, the Kaiser rule often overestimates the number of practical components within a given data set<sup>134</sup>.

Frequency distribution, including evaluation of skewness and kurtosis was also evaluated in this phase. Skewness and kurtosis represent the distribution of data in reference to the mean. Positive skewness indicates that most scores fall below the mean, while negative skewness indicates that most scores are located above the mean<sup>135</sup>. Kurtosis illustrates the amplitude of the distribution. Positive kurtosis (leptokurtic) indicates fatter tails and a narrow peak compared to a normal curve, while negative kurtosis (platykurtic) represents thinner tails and a wider peak, or plateau, when compared to a normal curve<sup>135</sup>. Certain criteria have been established to represent adequate measures of normally distributed data. Absolute values of the skewness statistic for each item  $>3$  suggests “extremely” skewed data, absolute values of the kurtosis statistic  $>10$  suggest “extreme kurtosis”<sup>135</sup>. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, version 19.0, Chicago, Illinois for Mac).

#### Phase 4: Convergent Validity

The purpose of phase 4 was to investigate convergent validity by assessing the relationship between scale responses and measures of self-reported function of the lower extremity. Convergent validity is a test used to assess the degree to which one measure is correlated with other measures that are theoretically similar<sup>133, 136</sup>.

#### Participants

Participants in Phase 4 consisted of 54 female basketball athletes (age=15.8  $\pm$ 1.3 years, height=178.3 cm  $\pm$  48.9, mass=65.9 kg  $\pm$ 11.6) from four Central Kentucky high schools. Before the study began, all participants provided written informed consent, and the University of Kentucky Institutional Review Board approved the study.

#### Instrumentation



The Foot and Ankle Abilities Measure (FAAM-S) sport subscale and Knee injury and Osteoarthritis Outcome Score (KOOS-S) sport subscale were used to establish function of the foot, ankle and knee for all of the participants. The FAAM-S is a reliable, responsive, and valid measure of physical function of the lower leg, foot, and ankle<sup>106</sup>. The KOOS-S is a valid, reliable and responsive self-administered instrument that can be used for short-term and long-term follow-up of several types of knee injury<sup>105</sup>. Both the FAAM-S and the KOOS-S result in a percentage of function out of 100 for both the left and the right limb. These measures were chosen because they have similar constructs evaluating the lower extremity and theoretically should be related to the SEBS.

### Procedures

All participants completed the SEBS Version 2.0, the FAAM-S and the KOOS-S<sup>105</sup>. Participants were instructed to read each question carefully and answer each to the best of their ability. Each participant had as much time as was needed to complete all questionnaires.

### Data Reduction

Scores from the FAAM-S and the KOOS-S were tabulated and right and left limbs were compared for differences. Because there is no clinical significance in evaluating each limb separately and no statistically significant difference between scores between the right and left limb was observed, the scores were compressed into one total score for the FAAM-S and one total score for the KOOS-S for each participant. Responses from each item on the SEBS were summed, divided by the number of items answered and multiplied by 100 to determine the final SEBS score.

### Statistical Analysis

Data was assessed for normal distribution using the Shapiro-Wilk statistic. It was determined the SEBS data was not normally distributed (significance

<0.05 indicated data was not normally distributed). Spearman's rank correlation was used to calculate the relationship between scores of SEBS and scores of the FAAM-S and KOOS-S measures to assess convergent validity. Strong to medium significant correlations indicate convergent validity. Correlation values can range from -1 to 1. Scores of 0.0 to 0.09 indicates no correlation, 0.1 to 0.3 indicates a small correlation, 0.3 to 0.5 indicates a moderate correlation, and 0.5 to 1.0 indicates a strong correlation<sup>137</sup>. The significance level for all analyses was set a priori at  $p \leq 0.05$ . Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, version 19.0, Chicago, Illinois for Mac).

## RESULTS

### Phase 1: Item Development and Determination of Face Validity

From the initial 17-item pool, the panel of experts made several suggestions. For clarity, item 9: "Going up or down stairs" was split into two separate items since the demands for these tasks are different. Additionally, item 14: "Jumping on one leg" and 15: "Landing on one leg from a jump", were altered to reflect a separate item for each limb. Several changes were made in wording of the items to make them clearer and easier to understand. For example, "jumping" was changed to "hopping" when it referred to a single limb activity.

Concern was raised from one panelist regarding a ceiling effect of the scale. A ceiling effect occurs when tasks on the scale are not challenging enough for individuals. Because the range of the scale is 0 to 100, there is a limit on the highest score possible. No items were added that increased task difficulty due to limitation of contextual tasks. The context of fundamental physical activity limits tasks that can be utilized.

### Phase 2: Content Validity

Assessment of content validity of the 21-item scale revealed that 16 items reached a positive CVR agreement, indicating that the majority of panelists rated the item to be 'essential' (see Table 3.1 for all CVR values). A CVR of 0 was

indicated for “Landing on both feet after dropping from a two-foot high surface”, “Going up stairs”, “Going down stairs”, and “Standing on your right/left leg with your eyes closed for 10 seconds” (right and left were two separate items). A CVR of 0 indicated that half of the panelists rated the items as ‘essential’, while the other half rated as “useful but not essential” or “not necessary”. Item 15 “Stopping short from a sprint” reached a CVR of 1, representative of 100% rater agreement. The content validity index (CVI), the mean for all retained items, was 0.46. Items that reached a positive CVR were retained and items that reached a CVR of 0 were flagged for removal.

### Phase 3: Construct Validity

Means, standard deviations, skewness, and kurtosis of items within the SEBS can be found in Table 3.2. A histogram of frequency distributions can be found in Figure 3.2. The first item: “*Running on a solid surface (gym floor or treadmill)*” resulted with a kurtosis statistic  $>10$ , suggesting this item is not distributed normally<sup>135</sup>. However all other items fell within the acceptable criteria for skewness and kurtosis. Overall, the distribution of scores was negatively skewed (skewness= -0.89; standard error of skewness=0.21) and leptokurtic (kurtosis= 1.1, standard error of kurtosis= 0.41). A leptokurtic distribution implies that the distribution curve had a narrower peak than the normal distribution curve.

Exploratory principal component analysis revealed a single dominant component of importance contained within the SEBS with an eigenvalue much greater than the others (10.44 vs. 1.97 and 1.48) in an un-rotated solution. The first component accounted for 49.7% of the total variance. The next largest component accounted for 9.4%. In attempting to assemble the most parsimonious and comprehensive model, a one-component model was satisfactory. A single dominant component implies that it is reasonable to combine all items into one score to represent the construct of perceived ability to balance. An orthogonal rotation analysis was attempted, but it did not provide any meaningful factors, indicating that no distinct cluster of patterns existed within the data<sup>138</sup>.

The results demonstrate that all 21 items had component scores greater than 0.50 (Table 3.3) indicating that none of the items were considered to be an outlier, and all items attributed at least 25% of the variance to the factor. The construct of self-efficacy of balance influenced the responses of each item. No additional items were flagged for removal from the scale in this phase. The only items that were flagged for removal occurred in phase 3. All items were retained for the final phase of this study.

#### Phase 4: Convergent Validity

Significant positive correlation was present between the dimensions on the FAAM-S and the SEBS ( $\rho = 0.34, p = 0.01$ ). A significant positive correlation was present between the dimensions of the KOOS-S and the SEBS ( $\rho = 0.32, p = 0.02$ ). Both  $\rho$  values for the FAAM-S and KOOS-S have a significant positive relationship to the SEBS. The FAAM-S accounted for 12% of the total variance of the SEBS. The KOOS-S accounted for 10% of the total variance of the SEBS.

## DISCUSSION

The overarching goal of this study was to develop a valid measure of self-efficacy of balance to address the psychological component of risk of injury for lower extremity injuries in a young, active population. Results of the four phases of this study provide evidence for the validity of the Self-Efficacy of Balance Scale (SEBS). The SEBS is a valid instrument for measuring self-efficacy of balance in a young, active population.

There was strong support for the scale's face validity as the items were constructed to purposefully include activities that were specific to the young, active population. A panel of experts determined that the SEBS measured the construct of self-efficacy of balance utilizing items that included fundamental activities for a young, active population. While face validity is more of a subjective assessment, it also helped to ensure the instrument had proper

grammar, was organized, flowed logically, and was easy to understand. As stated previously, the possibility of a ceiling effect was a concern from one panelist. The nature of physical activity (i.e. recreational activity, sports, etc.) limits the type of challenges that should be included on a self-efficacy scale<sup>73</sup>. If a challenge is not going to occur within the content domain than it is not relevant to the individual and will not offer much insight about self-efficacy.

Throughout the scale development literature, satisfactory content validity is often reported, but rarely is the method acknowledged<sup>133</sup>. An objective method of content validity or analysis is important to increase quality data. Although content validity, as measured through the content validity ratio (CVR) did not meet significance of 0.99 as suggested by Lawshe<sup>67</sup>, the majority of the items had positive CVRs. The rigorous guidelines that were established to objectively quantify content validity require a substantial amount of raters for the minimum CVR values to be met. A panel of six carefully selected expert raters was chosen in attempts to control the quality of the raters. In addition, construct and convergent validity further supported the results of content validity analysis. Items that resulted in lower CVR values have been used as representation of content validity in previous studies when a small numbers of raters were used<sup>130</sup>. Further analysis could be performed utilizing a larger number of expert raters, to help to increase CVR values of items within the SEBS, enhance the overall quality of the scale, and decrease the risk of chance agreements.

A method of flagging items was used to denote items that had the potential to be removed from the final version of the SEBS. If an item was flagged on two or more occasions, it was removed from the scale upon occurrence of the second flag. Items that had a CVR of 0 were flagged for removal because there was no clear agreement if an item was essential for the scale. This was the only point in which the items were flagged, consequently, these items did not meet the two flag criteria for removal and were retained in the scale. Additionally some of the items in question also provide investigators with a means of linking items on the SEBS to objective measures of testing. One test for postural control, the Balance Error Scoring System (BESS)<sup>111</sup>, utilizes the test

position of a single-limb balancing task with the eyes closed, which directly relates to the items (item 20 and 21) addressing confidence “*Standing on your right/left leg with your eyes closed for 10 seconds*”. No other phases resulted in the flagging of any items.

All items within the SEBS meet criteria for skewness and kurtosis. When evaluating the absolute values of the skewness and kurtosis statistic for each item, all were within one standard deviation from the mean, suggesting that no extremes were present<sup>135</sup>. The distribution of scores of the SEBS from the young, active population was negatively skewed, reflecting that a majority of SEBS scores were above the mean. This result reflects the population that was sampled. A young, active population had high levels of balance confidence. There were individuals that did score 100 on the SEBS. However the participants were young, active individuals who also scored high on the self-report of function scales as well, indicating they felt confident, and had no difficulty with lower extremity function.

Results of factor analysis demonstrated that the SEBS had a univariate construct, as originally hypothesized, which was labeled as self-efficacy of balance. The construct identified was able to explain a large portion of the total variance of responses, demonstrating one meaningful, independent, relationship among the items within the SEBS. All items contributed information to the self-efficacy of balance, indicating that a certain amount of perceived capability of balance was explained within each item. The structure of the SEBS was based on the constructs of self-efficacy, and its theory of perceived capability. Construct validity supported the theory that the SEBS was able to capture information about the perceived capability of balance in female basketball players. Due to the one factor model, it is reasonable to combine the scores from all of the items into one single score to represent balance confidence.

The correlations between the SEBS and the FAAM-S and the SEBS and the KOOS-S demonstrated a moderate correlation to support convergent validity. Similar scores were present on both measures of function, as well as SEBS, indicating the presence of overlapping constructs. This was hypothesized, as the

SEBS was adapted from items within the FAAM-S and the KOOS-S contains items that represent many of the fundamental situation that were evaluated within the SEBS. The SEBS was not subjected to tests of convergent validity with a measure of self-efficacy, however the SEBS was constructed based on methods suggested by Bandura<sup>33, 73</sup>, and adapted from items on the ABC scale, which has demonstrated validity and reliability in it's target population.

## LIMITATIONS AND FUTURE RESEARCH

There were limitations to this study. Within this study the SEBS was administered to a variety of participants. While participants were near the same age ( $17.3 \pm 1.66$  years, range 14-21), true activity levels can only be quantified in the 54 female high school basketball participants. Undergraduate students did report to be active, but intensity and frequency was not factored into inclusion criteria. However, this only affected the factor analysis phase of this study. The SEBS requires testing in a wide range of young active individuals to determine the utility of the SEBS to represent balance confidence.

Future research is recommended to test the reliability and stability of the SEBS. In order for an instrument to be useful, it must pass the rigors of proper psychometric testing. Employing the known-group technique to determine the degree to which an instrument can reveal different scores for groups known to vary on the variables that are being measured, would be useful to detect discriminant validity<sup>139</sup>. Administration of the SEBS to a group known to have decreased self-efficacy of balance and a group known to have good self-efficacy of balance will test the instruments ability to discriminate between the groups based on the results of the SEBS. To determine if the SEBS is able to detect clinically important changes over time it is important to explore scale responsiveness. Use of this scale in the future may provide important insights into the relationship between balance confidence and objective measures of balance in the young, active population.

## CONCLUSION

Preliminary results suggest that the SEBS is a valid instrument for measuring the self-efficacy of balance in female high school basketball players. The use of the SEBS in future research may provide important insights into young, active individuals' perceptions of ability to balance, resulting in an objective psychological measure for balance. The utility of the scale needs to be verified by replication of this study in other populations.



Table 3.1. Content Validity Ratios for the Self-Efficacy of Balance Scale (SEBS)  
Version 2.0

Item	Content Validity Ratio (CVR)
1. Running on a solid surface (gym floor or treadmill)	0.67
2. Jumping as high as you can with both feet	0.67
3. Bending over to pick up a shoe from the floor while standing on one leg	0.33
4. Landing on both feet after dropping from a two-foot high surface	0.00
5. Standing on tip toes reaching for something above your head	0.33
6. Standing on your right leg with your eyes open for 10 seconds	0.33
7. Standing on your left leg with your eyes open 10 seconds	0.33
8. Running outside on an uneven surface (on a muddy field or on a trail in the woods)	0.67
9. Going up stairs	0.00
10. Going down stairs	0.00
11. Walking across an uneven surface (a grass lawn or uneven road)	0.67
12. Squatting down to the floor while standing on both feet	0.33
13. Cutting or performing side-to-side movements while running with your right foot	0.67
14. Cutting or performing side-to-side movements while running with your left foot	0.67
15. Stopping short from a sprint	1.00
16. Hopping off of your right foot	0.33
17. Hopping off of your left foot	0.33
18. Landing on your right foot from a jump	0.67
19. Landing on your left foot from a jump	0.67
20. Standing on your right leg with your eyes closed for 10 seconds	0.00
21. Standing on your left leg with your eyes closed for 10 seconds	0.00

Table 3.2. Means, Standard Deviations (SD), Skewness, and Kurtosis Statistics

Item	Mean	SD	Skewness	Kurtosis
1. Running on a solid surface (gym floor or treadmill)	9.43	1.11	-2.83	10.49
2. Jumping as high as you can with both feet	8.74	1.74	-2.25	7.06
3. Bending over to pick up a shoe from the floor while standing on one leg	7.74	2.19	-1.15	1.18
4. Landing on both feet after dropping from a two-foot high surface	8.71	1.80	-2.08	5.28
5. Standing on tip toes reaching for something above your head	8.86	1.48	-1.61	2.68
6. Standing on your right leg with your eyes open for 10 seconds	8.73	1.60	-1.33	1.19
7. Standing on your left leg with your eyes open 10 seconds	8.54	1.77	-1.39	1.97
8. Running outside on an uneven surface (on a muddy field or on a trail in the woods)	8.25	1.74	-1.27	1.22
9. Going up stairs	9.30	1.11	-2.33	6.65
10. Going down stairs	9.20	1.30	-2.34	5.99
11. Walking across an uneven surface (a grass lawn or uneven road)	8.78	1.36	-1.27	1.62
12. Squatting down to the floor while standing on both feet	8.82	1.73	-2.16	6.17
13. Cutting or performing side-to-side movements while running with your right foot	8.34	1.95	-1.72	4.03
14. Cutting or performing side-to-side movements while running with your left foot	8.19	1.99	-1.33	1.91
15. Stopping short from a sprint	8.21	1.90	-1.55	3.12
16. Hopping off of your right foot	8.48	1.95	-2.00	4.93
17. Hopping off of your left foot	8.27	1.82	-1.21	1.44
18. Landing on your right foot from a jump	8.13	1.98	-1.42	2.43
19. Landing on your left foot from a jump	7.70	2.23	-0.97	0.46
20. Standing on your right leg with your eyes closed for 10 seconds	8.20	1.83	-1.07	0.89
21. Standing on your left leg with your eyes closed for 10 seconds	7.95	2.03	-1.04	1.09

Table 3.3. Component Loadings for the Self-Efficacy of Balance Scale (SEBS)  
Version 2.0

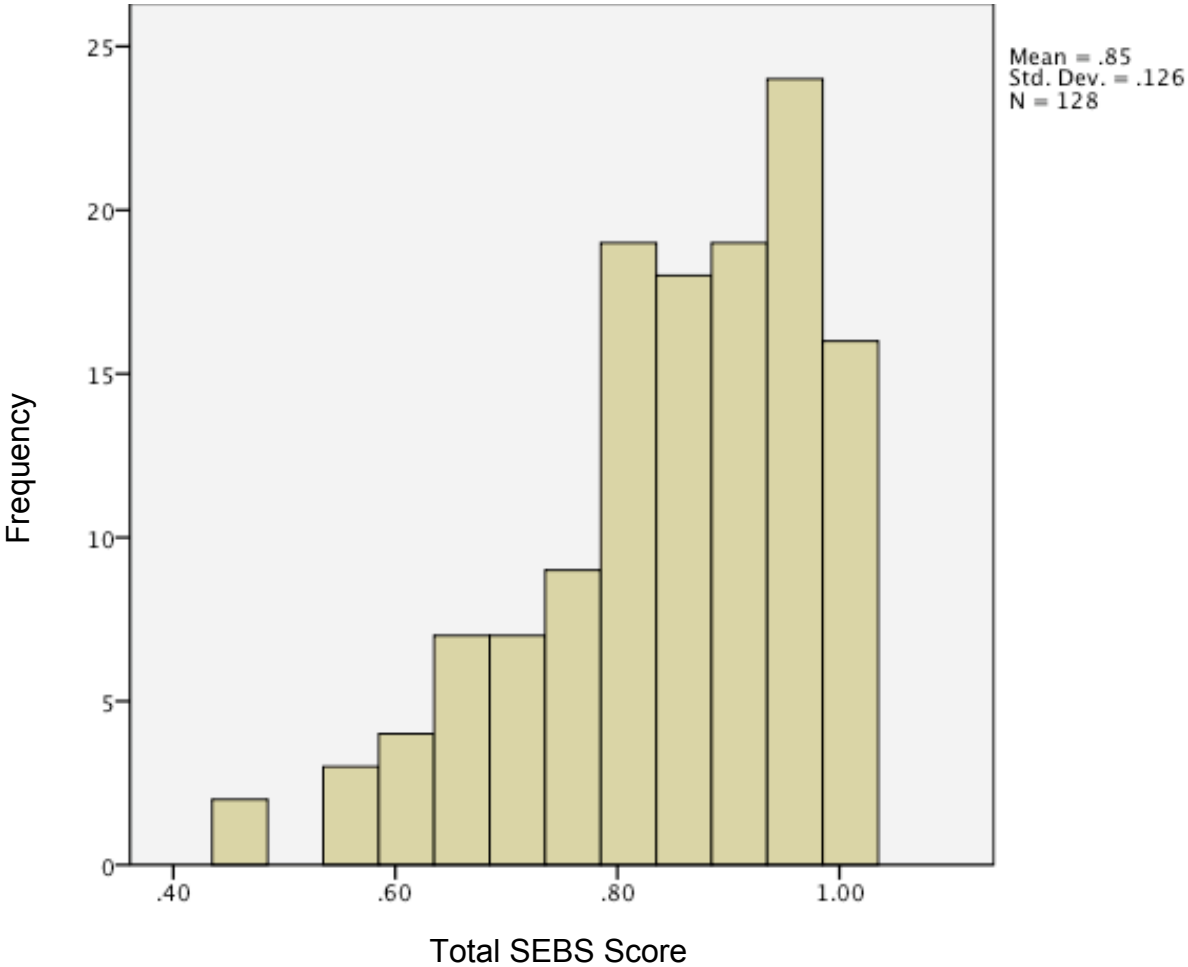
Item	Component Loading for First Factor
1. Running on a solid surface (gym floor or treadmill)	0.56
2. Jumping as high as you can with both feet	0.65
3. Bending over to pick up a shoe from the floor while standing on one leg	0.58
4. Landing on both feet after dropping from a two-foot high surface	0.59
5. Standing on tip toes reaching for something above your head	0.68
6. Standing on your right leg with your eyes open for 10 seconds	0.69
7. Standing on your left leg with your eyes open 10 seconds	0.72
8. Running outside on an uneven surface (on a muddy field or on a trail in the woods)	0.71
9. Going up stairs	0.52
10. Going down stairs	0.55
11. Walking across an uneven surface (a grass lawn or uneven road)	0.74
12. Squatting down to the floor while standing on both feet	0.69
13. Cutting or performing side-to-side movements while running with your right foot	0.82
14. Cutting or performing side-to-side movements while running with your left foot	0.82
15. Stopping short from a sprint	0.79
16. Hopping off of your right foot	0.79
17. Hopping off of your left foot	0.79
18. Landing on your right foot from a jump	0.80
19. Landing on your left foot from a jump	0.82
20. Standing on your right leg with your eyes closed for 10 seconds	0.68
21. Standing on your left leg with your eyes closed for 10 seconds	0.70

Figure 3.1 Content Validity Ratio Equation

$$\text{CVR} = \frac{n_e - N/2}{N/2}$$

Note:  $n_e$  = The number of panelists that rate an item as 'essential'.  
 $N$  = The total number of panelists

Figure 3.2. Histogram of Self-Efficacy of Balance Scale (SEBS) Scores



## Chapter 4: Reliability Testing of the Self-Efficacy of Balance Scale in a Young, Active Population

### INTRODUCTION

Modifiable risk factors of lower extremity injuries have been an important area in prevention of injuries for researchers and clinicians alike. Research investigating modifiable risk factors such as poor balance<sup>22, 95</sup>, decreased neuromuscular control of the trunk<sup>3, 15, 25</sup> and thigh musculature<sup>3, 15, 24, 25, 28, 94</sup>, and biomechanical dysfunction related to increased valgus knee moments during landing from a jump<sup>10, 28, 90, 91</sup> has been extensive. While identification of these risk factors have provided clinicians screening mechanisms to help to identify those at an increased risk for experiencing a lower extremity injury, important information may be absent. The influence of psychological factors on the risk of lower extremity injury from sport participation has not been fully investigated<sup>31</sup>. Research in sports medicine has addressed psychological aspects of the young and active, in regards to return-to-participation following injury<sup>140</sup> and post-injury rehabilitation<sup>47-49</sup>, but has not investigated any psychological risk factor for lower extremity injuries. The theory that psychological characteristics, such as confidence, could potentially predispose athletes to injury has not been thoroughly investigated.

The concept of self-efficacy is considered an individual's perception of their capabilities to complete specific tasks or perform in a specific situation<sup>36</sup>. Self-efficacy is largely based on an individual's cognitive appraisal of previous performances and experiences, but can also be influenced by social and physiological factors<sup>40</sup>. Recently, the influence of injury on self-efficacy has been explored in athletes who have sustained anterior cruciate ligament (ACL) injuries<sup>47, 48</sup>. It was demonstrated that patients' preoperative perceived self-efficacy of knee function predicted postsurgical outcomes<sup>48</sup>. Individuals with high levels of knee function self-efficacy had better outcomes than those with lower levels of knee function self-efficacy one year after surgery. While this model is important in regards to identifying individuals that might have better outcomes following injury with rehabilitation, the information does not help to identify those at risk for an injury. The relationship between self-efficacy and

outcomes following injury exists. However, it has not been determined if self-efficacy can be utilized to help predict injury in individuals that are at a higher risk of injury.

Self-efficacy of balance, the confidence an individual has in his or her balance has been investigated in the balance deficient population as a predictor of injury. Elderly individuals who had low measures of balance self-efficacy also had lower objective measures of balance, increased fall risk, restriction of activity, loss of independence and reduced quality of life than those with higher levels of balance self-efficacy<sup>57, 59, 60</sup>. Balance self-efficacy represents a quantifiable psychological component of balance related behavior in the elderly population<sup>57</sup>. There is a strong relationship between self-efficacy of balance in the older, balance deficient population, but this has not been thoroughly examined in the young, active population.

The relationship between self-efficacy and balance in a young, active population is important to establish. Young individuals who participate in sports and recreational activities are already at a high risk of sustaining a lower extremity injury<sup>61</sup>. As previously stated, poor balance is a risk factor for lower extremity injury. Currently, neuromuscular control and biomechanics are assessed using specific clinical and very technical laboratory measures. Examining the concept of self-efficacy of balance in the young, active population would provide a rich, patient-oriented, psychological measure that is needed to enhance evidence-based practice, which is not present at this time. Self-efficacy of balance might be able to provide insight to additional risk factors that are currently not being assessed. Additionally, a measure of evaluating self-efficacy of balance would be an efficient, inexpensive method for clinicians to use as a screening instrument for identifying those at risk for a lower extremity injury, especially in a high school setting where resources may be limited.

The Self-Efficacy of Balance Scale (SEBS) was created to measure self-efficacy of balance in a young, active population. The SEBS was developed with the intent to provide clinicians with an inexpensive clinical instrument to assess the psychological aspects of lower extremity injury risk. As stated previously, the concept of assessing self-efficacy of balance in the young active population has not been investigated, therefore, it is necessary that this instrument be methodically inspected to establish consistency and reliability. Psychometric testing demonstrated good face, construct,

and content validity for the SEBS. However, its internal consistency and reliability have not been established. Therefore, the purpose of this study was to examine both internal consistency and test-retest reliability of the SEBS in a young, active population. It is hypothesized that the SEBS will have good internal consistency as well as test-retest reliability over the course of three test sessions.

## METHODS

### Study Design

The testing of internal consistency and test-retest reliability of the SEBS was conducted in two parts. Part 1) Internal consistency was tested to determine uniformity of results across items within the SEBS, and indicate how well items on a scale correlate theoretically<sup>133, 141</sup>. Part 2) A test-retest design was used to evaluate reliability utilizing a cohort of female high school basketball players. Participants were tested on three separate occasions to measure test-retest reliability.

### Part 1: Internal Consistency

#### Participants

A total of 128 subjects participated in the internal consistency portion of this study. These participants consisted of 74 (age= 18.4± 0.7) university undergraduate students who were enrolled in a health science class and 54 (age= 15.8 ± 1.3) female high school basketball athletes from four Central Kentucky high schools.

#### Instrumentation

The SEBS Version 2.0 (See Appendix B) is a psychometric measure comprised of 21 items inquiring about an individual's balance confidence in a variety of situations. It is specific to the young, active population who engage in activities such as jumping, landing, running, and making quick movements (eg. cutting) during sport participation. Respondents make judgments of confidence in maintaining balance and body control for each item on the SEBS. Each of the 21 items within the scale has an 11-point Likert response alternative ranging from a score of 0 or "not confident", to 10 or "extremely confident".



## Procedures

The SEBS was administered to each participant for completion. Each participant was instructed to answer each item to the best of their ability. The participants were given as much time as was needed to complete the SEBS. The SEBS was then collected and data was de-identified.

## Data Reduction

To score the SEBS for each participant, responses from the 21 items were summed, divided by 21, and then multiplied by 100 to obtain a total percentage of balance confidence. The lowest possible score for the SEBS was 0, indicating no balance confidence at all, and the highest possible score was 100, indicating total balance confidence.

## Statistical Analysis

Cronbach's alpha coefficient<sup>142</sup> was used to calculate internal consistency of scores from T1. The minimum alpha value when using a clinical tool is 0.90, and an alpha value of 0.95 is desirable. Though when using a scale for research purposes, alpha values of 0.7 to 0.8 are considered satisfactory<sup>141</sup>. A very high ( $\geq 0.95$ ) Cronbach's alpha may indicate correlations among the items within the scale, or redundancy of one or more items<sup>143</sup>.

The significant level for analyses was set a priori at  $p \leq 0.05$ . All statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, version 19.0, Chicago, Illinois for Mac).

## Part 2: Test-retest Reliability

### Participants

A subgroup of the participants consisted of 16 female basketball athletes (age=15.7  $\pm$ 1.5 years) from one Central Kentucky high school. Before the study began, all participants provided written informed consent, and the University of Kentucky Institution Review Board approved the study. Participants were included if they were currently participating in an interscholastic high school basketball team. Participants were excluded if they did not have medical clearance for full participation

in basketball, had a concussion and were currently experiencing symptoms, had been diagnosed with another injury or disease known to affect balance (vertigo, sinus infection, inner ear infection, or vestibular disorders), or if they were currently pregnant or there was a chance of pregnancy. These participants were currently participating in basketball related activities (practices and conditioning).

### Instrumentation

The SEBS Version 2.0 (See Appendix B) is a psychometric measure comprised of 21 items designed to assess an individual's balance confidence in a variety of situations. It is specific to the young, active population who engage in activities such as jumping, landing, running, and making quick movements (e.g. cutting) during sport participation. Respondents make judgments of confidence in maintaining balance and body control for each item on the SEBS. Each of the 21 items within the scale has an 11-point Likert response alternative ranging from 0 or "not confident", to 10 or "extremely confident". Total scores can range from 0 to 100%.

### Procedures

All participants completed the SEBS on day 1 (T1). Each participant was assigned a participant number corresponding to the appropriate data, and data was de-identified. On days 7 (T2) and 14 (T3) participants completed the SEBS for the second, and third time respectively. The time interval between the first test, and the retest, was long enough that respondents did not remember their original answers, but not long enough for their knowledge of the items to have changed<sup>133</sup>. More realistic estimates of variability are found in the one-to-two week time interval as compared to a shorter time period for retest is used<sup>144</sup>. For this reason, a 7-day time interval was chosen.

Three administrations of the SEBS were conducted to examine the response of items on the SEBS. It is possible that the participants may not have been familiar with all tasks contained within items on the SEBS before the first test was administered. Since judgment of self-efficacy is largely based on an individual's cognitive appraisal of previous performances and experiences, an accurate judgment of novel tasks is

unlikely. For example, items 20 and 21 on the SEBS require the participant to judge confidence in balance while “*Standing on your right/left leg with your eyes closed for 10 seconds*”. If the participant has never performed a single-limb balance task with no visual input, it would be difficult to judge confidence. To account for the novel tasks within the SEBS, all participants performed novel tasks that were included within the SEBS during the first testing session following the first administration of the SEBS. Three test sessions were implemented to account for this learning effect. Testing on the following test sessions allow participants to reflect on previous experience performing the tasks that were novel. Therefore a more accurate judgment of self-efficacy of balance can be made on T2 and T3 sessions.

### Data Reduction

To score the instrument, each response from the 21 items was summed, divided by 21 and then multiplied by 100 to obtain a total percentage of balance confidence. The SEBS total scores were tabulated for each time-point (T1 to T3) and placed into an equation to calculate the interclass correlation and 95% confidence intervals to determine test-retest reliability. The lowest possible score for the SEBS was 0, indicating no balance confidence at all, and the highest possible score was 100, indicating total balance confidence. There was 100% follow-up for all three time periods.

### Statistical Analysis

Test-retest reliability examined the variation in responses of the same people, to the same instrument, at different time points. In this case, three points were used to accurately reflect true variance. The correlation between the scores indicates the stability of the instrument<sup>133</sup>. Comparisons were made between T1 and T2, T1 and T3, and T2, and T3. The intraclass correlation coefficient (2,1) (ICC 2,1) was used to evaluate test retest reliability over the three time points. The ICC (2,1) provides an estimate that includes the variability of measurements taken on the same subjects completing the same instrument, at different time points. ICC values between 0.4 and 0.75 represent fair to good reliability, and values  $\geq 0.75$  represent excellent

reliability<sup>145</sup>. The significance level for all analyses was set a priori at  $p \leq 0.05$ . All statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, version 19.0, Chicago, Illinois for Mac).

## RESULTS

### Part 1: Internal Consistency

The internal consistency of the SEBS was 0.95 for the total test, as calculated with Cronbach's alpha. When the alpha coefficient was calculated for the overall scale by eliminating each of the 21 items one at a time, the range was 0.94-0.95 (see Table 4.1). Deletion of items from the scale did not cause substantial changes in the alpha values, suggesting that the items had strong positive correlations with each other.

The average SEBS score was  $85\% \pm 12.6$  (median, 87%; range 46 to 100). The distribution of scores was negatively skewed (skewness, -0.89; standard error of skewness, 0.21) and leptokurtic (kurtosis, 1.1, standard error of kurtosis, 0.41). A leptokurtic distribution implies that the distribution curve has a narrow peak compared to a normal distribution curve<sup>135</sup>.

### Part 2: Test-retest Reliability

No lower extremity injuries occurred throughout the two-week testing phase that might alter the responses of the participants. Test-retest reliability at T1 compared to T2 was 0.62 (CI= 0.32 to 0.92), for T1 compared to T3 the ICC was 0.57 (CI= 0.13 to 0.83), and the ICC for T2 compared to T3 was 0.84 (CI= 0.58 to 0.94).

## DISCUSSION

The purpose of this study was to determine internal consistency and test-retest reliability of the Self-Efficacy of Balance Scale. The hypothesis was to have good SEBS internal consistency and test-retest reliability in a young, active population. Results demonstrate that the SEBS is a reliable instrument with high internal consistency and stability in a young, active population.

The SEBS has acceptable levels of internal consistency. A high Cronbach's alpha (0.95) indicates that the items within the SEBS consistently measure the

underlying construct of self-efficacy of balance in a young, active population. The close correlations within the scale demonstrate that participants responded consistently from one item to the next resulting in an estimate of reliability for the instrument. This also indicates that the 21 items in the SEBS are measuring the same construct of self-efficacy of balance and item responses can be combined to form one total SEBS score. Internal consistency is crucial as this can affect the precision of a measurement. Good internal consistency that was demonstrated with the SEBS indicates that the true score is being obtained.

In this study, intraclass correlation coefficients were calculated to determine the reliability of repeated measures of the SEBS. The SEBS had high test-retest reliability between sessions T2 and T3. The recommended minimum standard for reliability is an ICC of 0.70<sup>146</sup>. Good reliability between T2 and T3 indicates that the scale was stable. Reliability between the other two comparisons, T1 to T2 and T1 to T3, were less favorable as the ICCs did not reach the minimal standard of 0.70. The lower reliability between T1 and T2, and between T1 and T3 was anticipated due to potential unfamiliarity with items, and was the rationale for the three time test sessions. Participants were not able to accurately judge self-efficacy of balance for novel tasks. Following achievement of the tasks during the first test session, participants were able to make more accurate and stable judgments of self-efficacy of balance during T2 and T3.

Participants might not have been familiar with all of the tasks that were contained within the items in the SEBS, which might have affected measures for T1. When individuals create self-efficacy expectations, past performances are often recalled to create a judgment of confidence for a given task. When there is no previous performance or experience to recall, an accurate judgment of self-efficacy cannot be made. One of the items within the SEBS asked participants to assess the level of confidence to maintain balance while “*Standing on your right leg with your eyes closed for 10 seconds*”. Balancing with no visual input is not a task that is commonly performed during sports or recreational activity, but it is a common clinical test of balance and postural control. Had the participants been exposed to single-limb

balancing with eyes closed, judgment of confidence might have been different resulting in a higher level of correlation between T1 and T2.

A higher reliability coefficient between T2 and T3 suggests that after being exposed to those novel tasks during the first test session (T1), participants were able to make a better judgment on confidence after experiencing the task. The higher correlation between T2 and T3 can be attributed to activities that were performed during the testing session at T1. After completing T1 SEBS, all participants were administered a series of clinical and functional tests. One test for postural control, the Balance Error Scoring System (BESS)<sup>111</sup>, utilizes the test position of a single-limb balancing task with the eyes closed. Exposing the participants to the task of single-limb balance with eyes closed established a point of reference. When asked to judge confidence in single-limb balance with eyes closed at T2, participants could reflect back on the previous performance.

Overall, participants reported high levels of self-efficacy of balance. The distribution of SEBS scores trended to the right of the curve. This indicates that a ceiling effect was present in this current measure in this particular population. Participants in this study were healthy, young, active basketball players. It appears the tasks contained within the SEBS did not represent situations where self-efficacy of balance was challenged in 15 individuals that participated in this study. It is not apparent if a ceiling effect limits the utility of this instrument, as the participants were healthy at the time of administration. However, the SEBS might be less sensitive to self-efficacy of balance for certain individuals who have high levels of balance self-efficacy.

## LIMITATIONS AND FUTURE RESEARCH

Although this scale shows positive results, several limitations must be recognized. Test-retest reliability from the first administration to the second was low, potentially due to lack of familiarity with certain tasks on the SEBS. To increase reliability of the SEBS, a participant familiarization session of items might be warranted before the SEBS is administered. The familiarization session would give participants an opportunity to actually perform the tasks they are asked to judge. Alternatively,

instructions to the participants, if unfamiliarity exists with any of the tasks, to omit that item, since an accurate assessment of self-efficacy cannot be made.

Replication of the current study in other young, active populations, including male participants would further investigate the utility of the SEBS. For the SEBS to be a useful instrument, it must be reliable regardless of sex or sport. In addition, assessing scale responsiveness is needed to detect clinically relevant changes over time, or with the influence of an intervention to enhance self-efficacy of balance. Meaningful clinical differences should also be established for the SEBS to determine how much change is clinically relevant in relation to balance behavior.

## CONCLUSION

The major objective of this study was to test internal consistency and test-retest reliability of the SEBS in a young active population. The SEBS is a reliable and stable measure of self-efficacy of balance in a young, active population following participation in balance activities. Reliability was needed to demonstrate a sound psychological instrument that will help to build to the body of evidence for risk factors for lower extremity injury. This is important in moving forward to assess the relationship between clinical and laboratory measures of balance and patient reported self-efficacy of balance.

Table 4.1. Means, Standard Deviation, and Internal Consistency Values for the Self-Efficacy of Balance Scale (SEBS)

Item	Mean	SD	Corrected Item-Total correlation	Cronbach's Alpha if item deleted
How confident are you that you can maintain your balance and body control while:				
1. Running on a solid surface (gym floor or treadmill)	9.49	0.93	0.52	0.95
2. Jumping as high as you can with both feet	8.79	1.72	0.60	0.94
3. Bending over to pick up a shoe from the floor while standing on one leg	7.87	2.06	0.55	0.95
4. Landing on both feet after dropping from a two-foot high surface	8.76	1.75	0.56	0.95
5. Standing on tip toes reaching for something above your head	8.92	1.41	0.65	0.94
6. Standing on your right leg with your eyes open for 10 seconds	8.74	1.58	0.66	0.94
7. Standing on your left leg with your eyes open 10 seconds	8.58	1.65	0.68	0.94
8. Running outside on an uneven surface (on a muddy field or on a trail in the woods)	8.27	1.71	0.67	0.94
9. Going up stairs	9.34	1.01	0.47	0.95
10. Going down stairs	9.30	1.10	0.49	0.95
11. Walking across an uneven surface (a grass lawn or uneven road)	8.87	1.23	0.70	0.94
12. Squatting down to the floor while standing on both feet	8.91	1.55	0.63	0.94
13. Cutting or performing side-to-side movements while running with your right foot	8.37	1.95	0.79	0.94
14. Cutting or performing side-to-side movements while running with your left foot	8.23	1.99	0.79	0.94
15. Stopping short from a sprint	8.26	1.84	0.77	0.94
16. Hopping off of your right foot	8.51	1.91	0.76	0.94
17. Hopping off of your left foot	8.33	1.72	0.76	0.94
18. Landing on your right foot from a jump	8.14	2.00	0.78	0.94
19. Landing on your left foot from a jump	7.80	2.13	0.80	0.94
20. Standing on your right leg with your eyes closed for 10 seconds	8.23	1.76	0.65	0.94
21. Standing on your left leg with your eyes closed for 10 seconds	8.04	1.89	0.67	0.94



## Chapter 5: Examining the Responsiveness of the Self-Efficacy of Balance Scale (SEBS) and the Relationship between the SEBS and measures of self-reported function and objective measures of balance

### INTRODUCTION

Lower extremity injuries are the most common sports related injury, with ankle injuries accounting for 40%, knee 25%, and thigh 14% of total lower extremity injuries reported<sup>61</sup>. More than 550,000 boys and 429,000 girls participated in interscholastic high school basketball teams during the 2009-2010 academic school year<sup>86</sup>. An average of 375,350 basketball-related injuries were treated in US emergency departments per year between 1997 through 2007<sup>62</sup>. According to injury tracking data, basketball players have the second highest lower extremity injury rate for males and females<sup>61</sup>

There is a major focus to reduce the number of injuries that occur in high school basketball. Many factors contribute to the risk of lower extremity injury<sup>147</sup>. The presence of particular modifiable risk factors, such as decreased neuromuscular control of the trunk and thigh musculature, and decreased balance have been recognized to increase the incidence of lower extremity injuries in young, active individuals<sup>3, 15, 20, 24, 25, 28, 94, 96</sup>. Moreover, female athletes are reportedly 4 to 6 times more likely to sustain a non-contact anterior cruciate ligament (ACL) injury than their male counterparts<sup>88, 89</sup>.

Prevention of lower extremity injuries by identifying individuals who possess certain modifiable risk factors has been widely researched. While techniques for screening modifiable risk factors can be quite useful, often they require expensive equipment, ample time and space. Additionally, current screening techniques commonly used are focusing on the physical aspect of injury using clinical and laboratory methods and do not address the psychological aspect of injury. Previous research suggests that injury reduction is not feasible without some kind of behavioral change<sup>66</sup>. The cognitive aspect of an individual gives insight concerning interpersonal knowledge and beliefs that can influence behavior<sup>66</sup>. An instrument that specifically accesses the patient's point of view to in relation to risk of injury is currently lacking from the screening process.

The Self-Efficacy of Balance Scale (SEBS) was developed to capture information regarding balance confidence. The instrument was created using Bandura's theory of self-efficacy, where behavior can be changed based on beliefs of an individual<sup>40</sup>. Self-efficacy is considered an individual's perception of their capabilities to successfully complete specific tasks or perform in a specific situation<sup>36</sup>. The SEBS assesses the degree of self-efficacy of an individual to balance in various activities that are considered fundamental for young, active individuals. Self-efficacy of balance represents a quantifiable psychological component in balance assessment. This additional evidence might potentially provide information about an individual's risk of lower extremity injury. For clinicians, the SEBS represents a simple, inexpensive instrument to identify the psychological aspect of injury risk without using much time or resources.

The SEBS has demonstrated reliability and validity for measuring self-efficacy in a young, active population. Therefore it is now possible to study the relationship between self-efficacy of balance and other measures of balance and function. It is also possible to evaluate responsiveness of the SEBS in the young, active population such as female high school basketball players. The purpose of this exploratory study was to investigate the responsiveness of the SEBS over the course of a 15-week season using a sample of female high school basketball players. These players will participate in a lower extremity injury prevention program and will be compared to players that do not participate in an injury prevention program. An additional purpose was to examine the relationship between SEBS scores, measures of lower extremity function, and objective measures of balance.

## METHODS

### Research Design

This investigation utilized a prospective quasi-experimental study design, employing a test-retest design, with an intervention and control group. Participants were tested at the beginning of the 2011-2012 high school

basketball season (pre-test) and at the end of the season (post-test) in their home gymnasium.

## Participants

Participants consisted of 54 female basketball athletes (age=15.8 ±1.3 years, height=178.3 cm ± 48.9, mass=65.9 kg ±11.6) from four Central Kentucky high schools. Participants were included if they were currently participating in one of four interscholastic high school basketball teams. Participants were excluded if they did not have medical clearance for full participation in basketball, had a concussion and were currently experiencing symptoms, had been diagnosed with another injury or disease known to affect balance (vertigo, sinus infection, inner ear infection, or vestibular disorders), or if they were currently pregnant or there was a chance of pregnancy. Before the study began, all participants provided written informed consent, and the University of Kentucky Institution Review Board approved the study.

## INSTRUMENTATION

### Self-Reported Outcomes

#### *Self-Efficacy of Balance (SEBS)*

The SEBS Version 2.0 (see Appendix A) is a psychometric instrument comprised of 21 items designed to assess an individual's balance confidence in a variety of situations. It is specific to the young, active population who engage in activities such as jumping, landing, running, and making quick movements. The SEBS asks respondents to judge confidence in maintaining balance and body control. Each of the 21 items within the scale has an 11-point Likert response alternative ranging from a score of 0 or "not confident", to a score of 10 "extremely confident". The SEBS was developed as a technique to assess the psychological aspects of lower extremity balance. Scores for the SEBS are reported in percentages. The responses from each item are summed and then

divided by the total number of items answered. A score of 100% indicates complete balance confidence and a score of 0% represents no balance confidence at all.

#### *Foot and Ankle Ability Measure Sport (FAAM-S)*

The FAAM-S is an 8 item self-report index related to sport activities and participation in regards to foot and ankle function<sup>129</sup>. The FAAM-S is a reliable, responsive, and valid measure of physical function of the lower leg, foot, and ankle<sup>129</sup>. Scores for the FAAM-S are reported in percentages, with 100% indicating no foot or ankle dysfunction, and 0% indicating total foot and ankle dysfunction.

#### *Knee injury Osteoarthritis Outcome Score (KOOS-S)*

The KOOS-S is a 10 item self-report index related to sport activities and participation in regards to the knee<sup>105</sup>. The KOOS-S is a valid, reliable and responsive self-administered instrument that can be used for short-term and long-term follow-up of several types of knee injury<sup>105</sup>. Scores for the KOOS-S are reported in percentages, with 100% indicating no knee dysfunction, and 0% indicating total knee dysfunction.

#### Measures of balance

##### *Balance Error Scoring System (BESS)*

The BESS is a clinical method of assessing postural stability by measuring errors made during single-limb stance with eyes closed<sup>111, 124</sup>. Each participant completed three 20-second trials of a single-limb stance bilaterally, on a solid surface with the eyes closed to assess the BESS. Counting the number of errors that a subject made within each 20-second trial derived the score of the BESS. An error was recorded if the subject lifted the hands off the iliac crests, opened the eyes, stepped, stumbled, fell, remained out of the test position for more than five seconds, moved hip into more than 30° of flexion or abduction, or lifted the

forefoot or heel<sup>111</sup>. The number of errors each subject made were counted and recorded.

### *Static Postural Control*

To assess static postural control, each participant completed six 10-second trials of single-limb standing on a portable force plate (three trials of eyes open on both limbs). Participants were asked to focus on an eye-level marker on a wall in front of them located 1 meter away. Both limbs were tested. If, during a trial, a participant touched down with their opposite limb or had to use their arms to maintain balance, the trial was stopped and repeated. Static postural control was measured with TTB measures, using the Accusway Plus forceplate (AMTI; Watertown, MA). Center of pressure data were sampled at 50Hz. Center of pressure data from the forceplate was then categorized into anterior-posterior (AP) and medial-lateral (ML) directions and analyzed as TTB variables (mean of TTB ML minima, mean of TTB AP minima, standard deviation of TTB ML minima, and standard deviation of TTB AT minima)<sup>120</sup>. The TTB variables were exported and processed using a custom Matlab code (Version R2010b, MathWorks Inc. Natick, MA, USA) to result in values that represent the amount of time each individual has to make a postural correction (mean of TTB minima) in the AP or ML direction, and the number of solutions needed to maintain a single-limb stance given the boundaries of that individual's base of support (standard deviation of TTB minima) in the AP and ML direction. In both variables, higher values would indicate a greater amount of time to make corrections, or a greater number of solutions present to maintain the single-limb stance. Higher values for TTB variables indicate a higher functioning sensorimotor system, resulting in better balance<sup>120</sup>.

### Lower Extremity Injury Prevention Program

The injury prevention program was based on previous research that has demonstrated a reduction in functional ankle instability and reduced risk of ACL injuries<sup>7, 17, 97, 98, 148</sup>. The program focused on exercises that were designed to

increase balance of the lower extremity. Exercises consisted of dynamic hopping and landing components, core strength components, plyometric activities, lower extremity strengthening, and also focused on reaction time and producing quick changes of direction. An investigator trained the coaches on implementation and supervision of the program, and how to monitor progression. The coaches conducted the exercise program and helped the participants perform the injury prevention program. Session dosage was approximately 10-15 minutes in length, 3 times per week. All sessions were held in each team's respective gymnasium during regularly scheduled practices as part of a team's fitness training. Exercises progressed in difficulty throughout the season.

The coaches documented the completed injury prevention workouts in an exercise log. The log accounted for participant attendance, date of workout, and exercise protocol performed. The log also served as a means to track compliance. Compliance was determined by the number of team workouts completed per week throughout the season. An investigator monitored the documentation and the progression of the injury prevention program.

#### Procedures

Following consent, all participants completed the SEBS, followed by the FAAM-S and KOOS-S before participating in the balance tests (static balance assessment and BESS). Participants were instructed to read each question carefully and answer each to the best of their ability. Each participant had as much time as was needed to complete all questionnaires. Once the participant had completed all pre-test measures, questionnaires were collected and de-identified.

After the pre-test sessions, two of the teams were allocated to the control group (n=27) and participated in regular basketball related activities (practices, competitions, and conditioning) for the remainder of the season. The two remaining teams (n=27) were assigned to the intervention group. The intervention teams participated in a season-long lower extremity injury prevention program three times a week as well as scheduled basketball related activity. At

the conclusion of the 2011-2012 high school basketball regular season, participants completed post-testing, consisting of the same pre-test procedures.

#### Data Reduction

The independent variables were time (pre-test and post-test) and group allocation (control vs. intervention). The dependent variables were Self-Efficacy of Balance Scale (SEBS) scores, Foot and Ankle Ability Measurement Sport (FAAM-S) scores, Knee injury and Osteoarthritis Outcome Score Sport (KOOS-S) subscale, Time-to-Boundary (TTB) measures of postural control, and the Balance Error Scoring System (BESS) scores. Scores from the FAAM-S, KOOS-S, TTB, and BESS were tabulated and right and left limbs were compared for differences. Because there is no clinical significance in evaluating each limb separately and there was no statistically significant difference between scores of the right and left limb, the scores were compressed into one total score for the FAAM-S, one total score for the KOOS-S, one total score for each of the TTB variables, and one total score for the BESS for each participant for pre and post-testing sessions. Scores from the right and left limb were averaged to represent one composite score for each applicable outcome.

#### Statistical Analysis

Separate repeated measures ANOVAs were used to compare groups (control vs. intervention) across time (pre-test vs. post-test) for all dependent variables to assess scale responsiveness, change over time, and the influence of an intervention on dependent measures. Spearman's rank correlation coefficients were used to assess the relationship between SEBS scores and self-reported outcomes (FAAM-S, and KOOS-S) as well as measures of balance (TTB, and BESS scores). Correlation values can range from -1 to 1. Scores of 0.0 to 0.09 indicate no correlation, 0.1 to 0.3 indicate a small correlation, 0.3 to 0.5 indicates a moderate correlation, and 0.5 to 1.0 indicate a strong correlation<sup>137</sup>. The significance level for all analyses was set a priori at  $p \leq 0.05$ . All statistical

analysis was performed using the Statistical Package for Social Sciences (SPSS, version 19.0, Chicago, Illinois for Mac).

## RESULTS

Compliance to the injury prevention program was 88%. Over the course of 15 weeks the two intervention teams implemented the injury prevention program approximately 39 times out of a possible 45 sessions. At the time of the post-test, 9 participants were lost to follow-up in both the control and intervention groups. Two participants in the control group were no longer practicing with the team and two participants in the intervention group quit during the season. The remaining five participants (two from the intervention group and three from the control group) were not available for post-testing due to various reasons. Data from the pre-test sessions was carried forward for post-testing comparison.

### Self-Reported Outcomes

Means and standard deviations (SD) for the FAAM-S, the KOOS-S, and the SEBS are listed in table 5.1. No interaction was identified between the groups or time points. A main effect for time was found for the KOOS-S ( $p=0.01$ ), as well as the SEBS ( $p\leq 0.001$ ). Both groups' scores improved from pre-test to post-test, indicating that the SEBS was responsive to change in self-reported knee function. There was no significant difference between FAAM-S scores from pre-test to post-test. No group difference was present at time of pre-test reported for FAAM-S scores ( $p=0.85$ ), KOOS-S scores ( $p=0.06$ ) or SEBS scores ( $p=0.76$ ). No group difference was present at the time of post-test: FAAM-S scores ( $p=0.99$ ), KOOS-S scores ( $p=0.16$ ) and SEBS scores ( $p=0.79$ ).

There was a significant, positive relationship between the SEBS and the FAAM-S at pre-test. A significant, positive relationship between the SEBS and the KOOS-S was also present at pre-test. These results indicate that as scores increase on the SEBS, scores on the FAAM-S and KOOS-S also increase (see Table 5.2). A significant, positive relationship between the SEBS and the FAAM-



S was present at post-test and a significant, positive relationship between the SEBS and the KOOS-S was present at time of the post-test.

#### Balance Error Scoring System

Means and SD for the BESS are listed in Table 5.3. There was a significant difference between BESS scores at baseline, with the Intervention group having committed significantly fewer errors than the control group ( $p=0.001$ ). No effect for time was detected for BESS scores. Both the control and intervention group decreased the amount of errors made during the post-test when compared to the baseline; however, the decrease was not significant ( $p=0.45$ ). A significant difference between the intervention group and control group remained ( $p=0.001$ ). No significant relationship existed between the SEBS and the BESS ( $r=-0.01$ ,  $p=0.95$ ).

#### Static Postural Control

Means and SD for TTB measures are listed in Table 5.4. There was no effect for time or for intervention. A group differences was present for SD of TTB ML minima ( $p=0.04$ ), the intervention group had significantly more solutions for postural correction than the control group at post-testing. A significant, positive relationship between the SEBS and the mean of TTB AP minima ( $r=0.30$ ,  $p=0.02$ ) was detected from pre-test scores, and the mean of the TTB ML minima ( $r=0.30$ ,  $p=0.03$ ). Both correlations are considered at the moderate level.

## DISCUSSION

The first purpose of the study was to investigate the responsiveness of the SEBS in female high school basketball players who participated in a lower extremity injury prevention program compared to a control group. The SEBS was responsive to change in self-reported knee function, when a change was actually measured across all participants. The second purpose was to assess the relationship between scores on the SEBS with self-reported functional outcomes of the foot, ankle, and knee, as well as with objective measures of

balance. Investigating the correlation between the SEBS and measures of function of the lower extremity exposed the relationship between balance confidence, and how the individual assess his or her functional ability. Examining the relationship between the SEBS and commonly used objective measures of balance helped to demonstrate how self-efficacy of balance related to specific clinical and laboratory measures of balance.

Over the course of the 15-week season there was a significant increase in self-reported function of the knee, as indicated by KOOS-S scores, and an increase in self-efficacy of balance, as indicated by SEBS scores. This result indicates that the SEBS is responsive to change when a change was objectively measured in self-reported knee function. Scale responsiveness can be considered a method of longitudinal validity<sup>143</sup>. It was suspected that the SEBS would increase, if level of function increased. This indicates that the SEBS is able to distinguish participants who have and have not changed. Responsiveness is further supported by correlation values. The KOOS-S post-test correlation accounted for the largest portion of variance of the SEBS at post-testing. While the FAAM-S and mean TTB of the minima in the ML direction accounted for some variance of the SEBS, values were lower than KOOS-S correlation coefficients, and scores did not increase over time.

It appears that the lower extremity injury prevention exercise program had no significant effect on any of the dependent variables. Though, the intervention did not demonstrate improvement it also did not have deleterious effects on the participants as all participants' scores increased for the SEBS and the KOOS-S. The injury prevention program had good compliance as reported by the coaches, however exercise sessions were not supervised by the investigator, and relied on coaches' implementation of the program. While lower extremity injury prevention programs similar to the one used in this study have been successful in improving dynamic stability, physical therapists, certified in strength and condition were used to conduct exercise sessions and provide corrections on an athlete's form if needed<sup>11</sup>. Furthermore, a ratio of 4 athletes to 1 supervisor was utilized to conduct exercises session. Supervision by an experienced professional would

have been ideal, however not realistic. Many high schools have limited resources, and the idea of strength and conditioning professionals to implement an injury prevention program is not realistic. This study utilized the resources available to most coaches, minimal time, minimal equipment, and a simple prefabricated exercise program. The injury prevention exercise program was developed for the average high school setting where the coach is responsible for all strength and conditioning activities.

Balance is necessary for lower extremity function, and performance of fundamental tasks<sup>116</sup>. A positive correlation between the SEBS and the FAAM-S was present at baseline, as well as at time of post-test support this claim. The FAAM-S scores accounted for 12% of the variance in self-efficacy of balance at baseline and 14% of the variance in self-efficacy of balance at the time of post-test. Scores of the SEBS and the FAAM-S increased over the course of the basketball season, regardless of group. It was anticipated that scores from the FAAM-S would be related to the SEBS, as they are both evaluating function of the lower extremity. Although the FAAM-S accounts for some variance of the SEBS, it does not account for a large percentage of SEBS scores, indicating that the SEBS is measuring something other than just function of the foot and ankle.

A positive correlation between the SEBS and the KOOS-S was present at baseline, as well as at time of post-test. Scores from the KOOS-S, self-reported function of the knee, accounted for 10% of the variance in self-efficacy of balance at baseline and 23% of the variance in self-efficacy of balance at the time of post-test. Once more, the relationship between lower extremity function is associated with balance confidence in female high school basketball players. However, lower extremity function could only partly explain significant improvement in self-efficacy of balance. Similar relationships were reported in community dwelling elderly individuals. Lower extremity function was positively correlated with balance confidence, as measured by the ABC scale<sup>60</sup>. The level of function of an individual directly affects self-efficacy of balance. The relationship between self-efficacy of balance and lower extremity function further supports the hypothesis

that balance confidence would increase as function of the lower extremity increased.

When examining the relationship between self-efficacy of balance and objective measures of balance, a positive relationship was present at the time of the pre-test and post-test, however the relationships were not consistent. While the times an individual had to make a postural correction in the AP and ML direction both trended towards significant correlations at pre and post-testing, each fell out of significance in the post-test and the pre-test respectively. Though a moderate correlation between self-efficacy of balance and TTB measures exists, the clinical relevance should be considered carefully. While both measures are attempting to identify an aspect of balance, self-efficacy of balance increased significantly over time though there was no change in TTB measures. Had TTB measures increased over time the correlations might have remained consistent.

Significant relationships were obtained between the SEBS and TTB measures of postural control, yet there was no significant relationship between the SEBS and scores of the BESS. Explanation of the non-significant correlation might be due to the nature of the BESS. Evidence suggests that challenging balance tasks are likely to limit the influence of psychological factors on balance performance<sup>80</sup>. The single-limb testing position with eyes closed might have placed too great of a constraint on participants that balance confidence could not account for, in comparison to single-limb stance with eyes open with TTB methods.

Relationships between self-efficacy of balance and objective measures of balance were not consistent in this study. The inconsistent relationships could be due to the highly specific nature of the balance testing methods employed. TTB measures and the BESS only address balance in a static, single-limb stance. Items in the SEBS address a variety of tasks that require dynamic balance for successful completion, such as the Star Excursion Balance Test (SEBT)<sup>119</sup>. The SEBT is a objective measure of dynamic balance that incorporates postural control, strength, range of motion, and proprioceptive abilities of the lower

extremity<sup>113</sup>. Examining a more dynamic method of balance assessment might help to accurately assess the relationship between objective measures of balance testing and self-efficacy of balance.

#### LIMITATIONS/FUTURE RESEARCH

Although the SEBS demonstrates encouraging results, several limitations must be acknowledged. The participants were a specific group of young, active individuals, and results of this study can only be generalized to female high school basketball players. Second, several participants were unable to complete post-testing for a variety of reasons, resulting in a dropout rate of 17%. While the dropouts were spread across the groups evenly, utilizing the intent to treat method, required to carry scores from baseline forward to represent post-test scores. This might have limited the significance of some results. In addition, randomization of subjects and blinding of assessors would have strengthened study design and reduced bias.

The SEBS is a novel instrument used to assess self-efficacy of balance and will require further investigation to address overall utility of the instrument. Future research is recommended to include a more diverse group of participants to verify the relationships that were established in this population. In addition, utilizing the SEBS to discriminate between individuals with diminished balance capabilities, such as individuals with chronic ankle instability, from individuals with no history of injury would further promote use of the SEBS as a means of detecting risk of injury. Other implications of future research to include the SEBS would be a longitudinal study, investigating if low levels of self-efficacy of balance correlate with lower extremity injuries in the young, active population.

#### CONCLUSION

The SEBS is a fast, easy, economic instrument to assess a psychological component of balance. Preliminary results reveal a significant relationship between the SEBS and self-reported measure of lower extremity function, as well as an objective measure of balance in a young, active population. This study

suggests that self-efficacy of balance is likely to be influential in determining risk of lower extremity injury in the future. Further research will determine if the SEBS can be used as a screening instrument to assess risk of lower extremity injury.

Table 5.1. Pre vs. Post Means and SD of Self-Reported Outcomes

Self-Report Measures	Group	Pre-test	Post-test
FAAM-S %	Intervention	90.80± 12.20	91.49± 14.22
	Control	91.59± 17.94	94.91± 6.93
KOOS-S %	Intervention	92.59± 10.37	94.80± 9.01 <sup>a</sup>
	Control	81.84± 23.47	90.84± 11.27 <sup>a</sup>
SEBS %	Intervention	83.42± 13.04	88.31± 11.53 <sup>a</sup>
	Control	83.4± 10.71	89.17± 11.63 <sup>a</sup>

<sup>a</sup> Significant difference compared to pre-test ( $p \leq 0.05$ )

FAAM-S %= Foot and Ankle Ability Measure-Sport subscale % of 100

KOOS-S %= Knee injury Osteoarthritis Outcome Scale-Sport subscale % of 100

SEBS%= Self-Efficacy of Balance Scale % of 100

Table 5.2. Spearman's rho correlation coefficient between the Self-Efficacy of Balance Scale and self-reported measures of lower extremity function and objective measures of balance.

Variables	SEBS Pretest	SEBS Posttest
FAAM-S	0.34 <sup>a</sup>	0.37 <sup>a</sup>
KOOS-S	0.32 <sup>b</sup>	0.48 <sup>a</sup>
BESS	-0.13	-0.01
Mean TTB Minima AP (s)	0.31 <sup>b</sup>	0.25
Mean TTB Minima ML (s)	0.24	0.30 <sup>b</sup>
SD TTB Minima AP (s)	-0.03	0.15
SD TTB Minima ML (s)	-0.07	0.00

<sup>a</sup> Indicates correlation is significant ( $p \leq 0.01$ )

<sup>b</sup> Indicates correlation is significant ( $p \leq 0.05$ )

AP = anteroposterior

BESS= Balance Error Scoring System

FAAM-S= Foot and Ankle Ability Measure-Sport subscale

KOOS-S= Knee injury Osteoarthritis Outcome Scale-Sport subscale

ML = mediolateral

SD = standard deviation

SEBS= Self-Efficacy of Balance Scale

TTB = time-to-boundary



Table 5.3. Balance Error Scoring System Means and SD

Clinical Measure of Balance	Group	Pre-test	Post-test
BESS (Total number of errors)	Intervention	9.20± 5.00 <sup>a</sup>	8.94± 4.35 <sup>a</sup>
	Control	16.37± 9.46	15.82± 8.57

<sup>a</sup> Indicates a significant difference between Control group ( $p \leq 0.05$ )

BESS Balance Error Scoring System

SD = standard deviation

Table 5.4. Time to Boundary Means ( $\pm$ SD) for Static Postural Control

TTB Measure	Group	Pre-test	Post-test
Mean TTB Minima AP (s)	Intervention	4.78 $\pm$ 1.12	4.63 $\pm$ 1.24
	Control	5.05 $\pm$ 1.42	5.33 $\pm$ 1.57
Mean TTB Minima ML (s)	Intervention	1.63 $\pm$ 0.34	1.57 $\pm$ 0.39
	Control	1.74 $\pm$ 0.42	1.77 $\pm$ 0.42
SD TTB Minima AP (s)	Intervention	0.72 $\pm$ 0.19	0.72 $\pm$ 0.20
	Control	0.67 $\pm$ 0.16	0.72 $\pm$ 0.16
SD TTB Minima ML (s)	Intervention	0.51 $\pm$ 0.08	0.51 $\pm$ 0.10 <sup>a</sup>
	Control	0.48 $\pm$ 0.09	0.46 $\pm$ 0.08

<sup>a</sup> Indicates a significant difference between the Control group ( $p \leq 0.05$ )

AP = anteroposterior  
 ML = mediolateral  
 SD = standard deviation  
 TTB = time-to-boundary

## Chapter 6: Summary

The purpose of this dissertation was to develop an instrument to measure the self-efficacy of balance in a young active population within a series of three individual studies. The purpose of the first study was to develop items for a self-efficacy of balance instrument, and test the validity of the instrument. The purpose of the second study was to assess stability and reliability of the self-efficacy of balance instrument. Finally there were two purposes of the third study: 1) to establish whether the self-efficacy of balance instrument was responsive to change over time and with a lower extremity injury prevention program, and 2) to investigate the relationship between self-efficacy of balance and self-reported measures of lower extremity function and objective measures of balance.

**Hypothesis for Specific Aim 1:** Based on a developed scale that measures balance confidence in an older population; items can be developed to address individuals who are younger and more active. The SEBS will have good face validity as indicated by a panel of experts. The SEBS will have good content validity when assessed by an expert panel using Content Validity Ratio<sup>67</sup>. Construct validity will demonstrate that items on the SEBS will fit in a one-factor model. Convergent validity will demonstrate a direct positive relationship between the SEBS and self-report lower extremity function as measured by the Foot and Ankle Ability Measure Sport (FAAM-S) subscale and Knee injury and Osteoarthritis Outcome Sport (KOOS-S) subscale.

**Finding:** It was confirmed that items within the SEBS measured the construct of self-efficacy of balance to establish face validity. Content validity was established, and logically assessed using the content validity ratio (CVR). It was found that the majority of items contained within the SEBS had good agreement among the panelists. Factor analysis revealed one independent construct that accounted for a large part of the variance of the SEBS, which was labeled as self-efficacy of balance. Correlations between the SEBS and self-reported

measures of lower extremity function were present; as scores of the SEBS increased, lower extremity function of the foot, ankle, and knee increased.

**Hypothesis for Specific Aim 2:** The SEBS will be reliable when tested for internal consistency (Cronbach's alpha  $\geq 0.9$ ) as well as over time, with a test-retest method (Spearman's correlation coefficient  $\geq 0.8$ ).

**Finding:** This hypothesis was confirmed as the SEBS had good internal consistency when administered to a group of female high school basketball players. This hypothesis was confirmed in test-retest correlations between day 7 (time 2) and day 14 (time 3) in female high school basketball players on the SEBS. This hypothesis was not confirmed in test-retest correlations between day 1 (time 1) and day 7 (time 2) with a correlation of 0.62 falling below level of significance.

**Hypothesis for Specific Aim 3:** The SEBS will be responsive to change, if a change occurs in self-reported lower extremity function, or objective measures of balance. Following the 15-week, evidence-based lower extremity injury prevention program intervention, participants will increase self-efficacy of balance as indicated by SEBS scores compared to those who do not participate in an injury prevention program.

**Finding:** This hypothesis was confirmed in the responsiveness of the SEBS scale. The responsiveness of the SEBS was apparent as scores increased in all participants from pre to post-test in the KOOS-S and SEBS. This hypothesis was not confirmed with the 15-week intervention. There was no significant difference in SEBS scores across groups following the 15-week intervention.

**Hypothesis 3a:** There will be a direct positive relationship between self-efficacy of balance and self-report measures of lower extremity function as measured by the FAAM-S and KOOS-S.

**Finding:** This hypothesis was confirmed with significant positive correlations between SEBS scores and FAAM-S and KOOS-S scores. As SEBS scores increased, so did self-reported measures of lower extremity function.

**Hypothesis 3b:** There will be a direct positive relationship between self-efficacy of balance and objective clinical and laboratory measures of balance as measured by the Balance Error Scoring System (BESS) and Time to Boundary (TTB) measures of postural control.

**Finding:** This hypothesis was confirmed in 1 of the 2 objective measures of balance. The mean time to make a postural correction in the AP direction had significant positive relationship with self-efficacy of balance at time of pre-test and not post, while the mean time to make a postural correction in the ML direction was significant at the time of post-testing and not at pre-testing.

## SYNTHESIS AND APPLICATION OF RESULTS

The first study of this dissertation served to develop items to form the Self-Efficacy of Balance Scale (SEBS). Original scale items were adapted from self-efficacy of balance scales for assessing balance deficient populations. Item development went through systematic validity testing, demonstrated good face validity, good content, construct, and convergent validity in a young, active population. The final version of the instrument was a 21-item Self-Efficacy of Balance Scale for use in the young, active population. One factor was demonstrated for the SEBS making it reasonable to combine all of the items into one single total score that represents self-efficacy of balance. The results of this study established the foundation of the SEBS for further psychometric testing within the target population.

Following validation of the SEBS, the instrument was subjected to reliability testing. The SEBS had good internal consistency when administered to a group of young, active individuals. Participants responded similarly to items within the SEBS. In general the young, active population that was sampled had high levels of self-efficacy of balance as a group. Test-retest reliability, or reproducibility, demonstrated good results in a group of female high school basketball players. Following familiarization with novel tasks, which were contained within the SEBS, participants were able to consistently judge self-efficacy of balance with repeated measures. This study demonstrated the

importance of participant knowledge of tasks to be assessed for accurate and consistent judgment of self-efficacy. Participants were able to consistently judge self-efficacy of balance after acquiring knowledge and experience regarding novel tasks that were contained within the SEBS. This is an important characteristic of a rating scale. Scores did not change over time when the participants' function and activity did not change.

Responsiveness of the SEBS was measured in the third study. The SEBS was responsive to participants' increased self-efficacy of balance and self-reported knee function. The hypothesis was that the intervention group who had participated in the 15-week lower extremity intervention program would have significantly higher SEBS scores when compared to the control group. This was not the case as all participants' SEBS scores increased over the course of the 15-week season. It appears that self-efficacy of balance increases through participation in interscholastic basketball over the course of a season. This finding supports the basic tenets of self-efficacy. Successful execution of a behavior raises self-efficacy expectations, therefore individuals should be more confident about activities they engage in on a regular basis<sup>40</sup>. The SEBS contains items that address tasks that are fundamental to performance in the young active individual and many would be commonly performed within practice and competition.

There was a significant positive relationship between self-efficacy of balance and self-reported measures of lower extremity function in female high school basketball players. Over the course of the 15-week season, SEBS scores increased as well as FAAM-S and KOOS-S scores. However, significant improvement in self-efficacy of balance could only be partly explained by the improvement in self-reported lower extremity function as indicated by FAAM-S and KOOS-S scores. This suggests that there are other influences on the SEBS scores than lower extremity function. This further supports the need for a quantifiable psychological component in assessing risk of injury for the lower extremity. The SEBS is measuring a psychological aspect of balance that is not

currently being captured by clinical or laboratory methods that are currently being employed throughout the literature.

This study identified a significant relationship between SEBS scores and two TTB measures of postural control, however this relationship was not consistent. Though both variables were trending towards consistent significance pre and post-testing significance was not reached for both variables during both time points. There was no significant relationship between SEBS scores and BESS scores at pre or post-testing. No consistent relationship between self-efficacy of balance and objective measure of balance was demonstrated in this study. The lack of relationship between SEBS scores and objective measures of balance could be due to the highly specific nature of the balance testing methods employed. The SEBS addresses a variety of tasks that require balance for successful completion, however TTB measures and the BESS only address single-limb stance. Employing a more dynamic method of balance assessment might help to further accurately assess the relationship between objective measures of balance and self-efficacy of balance.

The results of the three studies included within this dissertation bring about interesting findings. Chapters 3, 4, and 5 demonstrated evidence of a psychometrically sound instrument. This indicates that the SEBS is a valid, reliable, responsive self-efficacy of balance instrument when evaluating young, active individuals. Chapter 5 also demonstrated the relationships between self-efficacy of balance, self-reported measures of function, and objective measures of balance. These relationships demonstrated that while lower extremity function and some measures of balance influence scores of the SEBS, they do not account for all of the variability of the SEBS. This finding further supports the claim that balance behavior is changing as function and postural control change. Future testing should include assessment of balance using several methods, including a more dynamic balance assessment, such as the Star Excursion Balance Test<sup>119</sup>. Assessment of dynamic balance might provide a stronger link between self-efficacy of balance and objective measures of balance.

Additionally, the SEBS must be evaluated for its utility among a range of young, active individuals to make the instrument more practical.

The SEBS will hopefully provide clinicians and researchers an instrument that can capture self-efficacy of balance information in the young, active population. This SEBS instrument can begin to fill the gap in the lower extremity injury prevention literature that currently exists. In the course of satisfying the gap in the literature, a quantifiable psychological component of balance may integrate knowledge from the behavioral science perspective into the orthopedic injury prevention literature. This will afford clinicians and researchers to utilize the SEBS into practice and further research. Significant contributing factors to lower extremity injury might be revealed with longitudinal testing of the SEBS. Longitudinal testing may lead to the creation of an efficient and inexpensive screening tool that may aid in the prevention of injury from a behavioral perspective. Furthermore, future research may also lead to the creation of prophylactic interventions designed to prevent injury based on a SEBS or SEBS like screening process.



**Self-Efficacy Balance Scale**

Please answer **every question** with one responderating your confidence level on a scale of 0 (not confident) to 10 (completely confident).

**How confident are you that you can maintain your balance while:**

	not confident										completely confident											
(Q1) Running on a solid surface (gym floor or treadmill)	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q2) Jumping off of both feet from the floor	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q3) Bending over to pick up a shoe from the floor while standing on one leg	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q4) Landing on both feet after dropping from a two-foot high surface	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q5) Standing on tip toes reaching for something above your head	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q6) Standing on your right leg with your eyes open for 10 seconds	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q7) Standing on your left leg with your eyes open 10 seconds	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q8) Running outside on an uneven surface (in the grass or on a road)	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q9) Going up or down stairs	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q10) Walking across an uneven surface (a grass lawn or uneven road)	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q11) Squatting down to the floor while standing on both feet	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q12) Cutting or performing side-to-side movements while running	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q13) Stopping short from a sprint	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q14) Jumping off of right foot	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q15) Jumping off of left foot	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q16) Landing on right foot from a jump	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q17) Landing on left foot from a jump	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q18) Standing on your right leg with your eyes closed for 10 seconds	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q19) Standing on your right leg with your eyes closed for 10 seconds	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10

## Appendix B: Self-Efficacy of Balance Scale Version 2.0

### Self-Efficacy Balance Scale

A number of situations are described below that can make it hard to maintain balance and control of your body. Please answer **each question** with one responderating how confident you are that you can keep your balance in each situation from 0 (not at all confident) to 10 (completely confident).

### How confident are you that you can maintain your balance and body control while:

	<i>notat all confident</i>										<i>completely confident</i>											
(Q1) Running on a solid surface (gym floor or treadmill)	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q2) Jumping as high as you can with both feet	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q3) Bending over to pick up a shoe from the floor while standing on one leg	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q4) Landing on both feet after dropping from a two-foot high surface	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q5) Standing on tip toes reaching for something above your head	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q6) Standing on your right leg with your eyes open for 10 seconds	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q7) Standing on your left leg with your eyes open 10 seconds	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q8) Running outside on an uneven surface (on a muddy field or on a trail in the woods)	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q9) Going up stairs	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q10) Going down stairs	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q11) Walking across an uneven surface (a grass lawn or uneven road)	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q12) Squatting down to the floor while standing on both feet	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q13) Cutting or performing side-to-side movements while running with your right foot	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q14) Cutting or performing side-to-side movements while running with your left foot	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q15) Stopping short from a sprint	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q16) Hopping off of your right foot	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q17) Hopping off of your left foot	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q18) Landing on your right foot from a jump	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q19) Landing on your left foot from a jump	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q20) Standing on your right leg with your eyes closed for 10 seconds	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
(Q21) Standing on your left leg with your eyes closed for 10 seconds	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10

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## Vita

Carrie Silkman Baker, MEd, ATC

### General Information

Birthplace and date: Danbury, CT 06/24/1978

### Education

Doctor of Philosophy University of Kentucky, Lexington, KY  
Rehabilitation Sciences  
Anticipated Graduation Date of May 2012

Masters of Science in Education Old Dominion University, Norfolk, VA  
May 2002  
Emphasis in Athletic Training

Bachelors of Science, Sports Medicine Castleton State College, Castleton, VT  
May 2000

### TEACHING EXPERIENCE

*Eastern Kentucky University, Richmond, KY*

**Adjunct Faculty 2011-Present**

ATR 100: Introduction to Athletic Training

PHE 212: Care and Prevention of Athletic and Exercise Injuries

*University of Kentucky, Lexington, KY*

**Guest Lecturer 2008-2011**

CHS 100: Health Care Professionals

AT 642: Scientific Inquiry in Athletic Training III

**Teaching Assistant Fall 2009**

AT 642: Scientific Inquiry in Athletic Training III

*Sacred Heart University, Fairfield, CT*

**Clinical Assistant Professor, 2004-2008**

AT 129: Athletic Training Clinical Practicum I

AT 220: Athletic Training Clinical Practicum II

AT 221: Athletic Training Clinical Practicum III

AT 342: Therapeutic Rehabilitation of Athletic Injuries

AT 310: Aspects of Clinical Medicine

HM 260: Kinesiology Lab

HM 100: Prevention of Athletic Injuries and Illnesses

**Adjunct Instructor, 2003-2004**

HM 100: Prevention of athletic injuries and illnesses

**PROFESSIONAL EXPERIENCE**

*Eastern Kentucky University, Richmond, KY*

**Approved Clinical Instructor, August 2011-Present**

*University of Kentucky, Lexington, KY*

**Research Coordinator, May 2011-Present**

*University of Kentucky, Lexington, KY*

**Doctoral Research Assistant in Athletic Training, August 2008-2011**

*Sacred Heart University, Fairfield, CT*

**On-Campus Clinical Coordinator/Clinical Assistant  
Professor/Assistant Athletic Trainer, 2004-2008**

*Sacred Heart University, Fairfield, CT*

**Interim Head Athletic Trainer, Summer 2003**

*Sacred Heart University, Fairfield, CT*

**Assistant Athletic Trainer/Approved Clinical Instructor, 2002-2004**

*Old Dominion University, Norfolk, VA*

**Graduate Assistant Athletic Trainer, 2000-2002**

*Castleton State College, Castleton, VT*

**Athletic Training Student, 1996-2000**

**CURRENT RESEARCH**

*“Development of a Self-Efficacy of Balance Scale”*

Silkman, C, McKeon, J, McKeon, P, Usher, E, Mattacola, CG, Uhl, T,  
Capilouto, G

*“Interscholastic sports injury surveillance and prevention in rural Kentucky: A pilot study”*

Silkman, C, McKeon, J

*“Postural control, knee alignment, and self-reported function in patients with symptomatic knee osteoarthritis and normal control subjects”*

Silkman, C, McKeon, J

“Evaluation of two-dimensional motion analysis as a screening tool: A validation of 2D versus 3D motion analysis”

Kavanaugh, C, Silkman, C, McKeon, P, McKeon, J

## MANUSCRIPTS

**Silkman, C.**, McKeon, J. The Effect of Preoperative Quadriceps Strength on Strength and Function following Anterior Cruciate Ligament Reconstruction (Critically Appraised Topic). *Journal of Sport Rehabilitation*, 2012; 21(1).

Dolak, K, **Silkman, C**, Uhl, T, McKeon, J, Lattermann, C, Hosey, R. The Comparison of Early Hip Strengthening to Early Quadriceps Strengthening in the Treatment of Females with Patellofemoral Pain Syndrome. *J Orthop Sports Phys Ther* 2011;41(8):560-570. Epub 7 June 2011. doi:10.2519/jospt.2011.3499

**Silkman C**, McKeon J. The effectiveness of electromyographic biofeedback supplementation during knee rehabilitation after injury. *Journal of Sport Rehabilitation*. 2010;19(3).

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## MANUSCRIPTS IN REVIEW

**Silkman, C.**, McKeon, J. Effectiveness of Preoperative Rehabilitation for Total Knee Arthroplasty: A Systematic Review.

Grubb, L, **Silkman, C**, McKeon, P, Mattacola, C, McKeon, J  
Self reports of pain and function are diminished in otherwise healthy collegiate athletes who have undergone ACL reconstruction 1 – 5 years prior

## REFEREED ABSTRACTS

**Silkman, C.** McKeon, J., Howard, J., Mattacola, CG. Representative Data for Functional Tasks on the Neuorcom for Those With and Without Intra-articular Knee Pathology. *Journal of Athletic Training*. 2010; 45 (Supplement)

McKeon, J. **Silkman, C.**, Dolack, K., Uhl, T., Latterman, C., Hosey, A  
Comparison of Early Hip Strengthening to Early Quadriceps Strengthening in the  
Treatment of Females with Patellofemoral Pain Syndrome” (Strength data). *PRS*,  
May 2010 Teeside, England. Oral Presentation

Hoch MC, McKeon PO, McKeon JM, **Silkman C.** Adolescents demonstrate lower  
spatiotemporal postural control compared to healthy adults. *National Athletic  
Trainer’s Association Annual Convention and Symposium*. San Antonio, TX,  
June 2009.

Dolak, K, **Silkman, C**, Uhl, T, McKeon, J, Lattermann, C, Hosey, R. Comparison  
of Early Hip Strengthening to Early Quadriceps Strengthening in the Treatment of  
Females with Patellofemoral Pain Syndrome (Pain Data). *National Athletic  
Trainer’s Association Annual Convention and Symposium*. San Antonio, TX,  
June 2009.

## **PRESENTATIONS**

**Silkman C, McKeon J.** Postural Control, Knee Alignment, And Self-reported  
Function In Patients With Symptomatic Knee Osteoarthritis And Normal Control  
Subjects. *American College of Sports Medicine Annual Meeting*. San Francisco,  
CA, May 2012. Poster Presentation

**Silkman C, McKeon J.** The Role of Gender in Physical Self-efficacy and  
Balance Among High School Basketball Players. *National Athletic Trainer’s  
Association Annual Convention and Symposium*. New Orleans, LA, June 2011.  
Poster Presentation

**Silkman, C.** McKeon, J. Effects Of Preoperative Rehabilitation In Individuals  
Who Have Undergone Total Knee Arthroplasty: A Systematic Review. *American  
College of Sports Medicine Annual Meeting*. Denver, CO, June 2011. Poster  
Presentation

**Silkman, C.** Targeting the Hip: Strengthening of Hip Musculature to Reduce Pain  
and Improve Function in Patients with Patellofemoral Pain Syndrome (PFPS).  
*National Athletic Trainer’s Association Annual Convention and Symposium*.  
Philadelphia, PA, June 2010. Oral Presentation

**Silkman, C.** McKeon, J., Howard, J., Mattacola, CG. Representative Data for  
Functional Tasks on the Neuorcom for Those With and Without Intra-articular  
Knee Pathology. *National Athletic Trainer’s Association Annual Convention and  
Symposium*. Philadelphia, PA, June 2010. Oral Presentation

Dolak K, Uhl T, Medina McKeon J, **Silkman C**, Hosey R, Lattermann C.  
Comparison of Early Hip Strengthening to Early Quadriceps Strengthening in the



Treatment of Females with Patellofemoral Pain Syndrome. *National Athletic Trainers' Association Annual Convention and Symposium, San Antonio, TX; June 19, 2009*. Oral Presentation:  
Published: *Journal of Athletic Training* 2009 May-Jun; 44(3 suppl):S-67

**Silkman, C.**, Hoch, M. Getting a Leg Up on Lower Extremity Functional Rehabilitation. *Breakout Session, Wildcat Symposium, May 2009*. Oral Presentation

**Silkman, C.**, May, S., Luers, M. Acute Proprioceptive Measurements Following Traditional, Functional, and a Combination of Both Ankle Rehabilitative Exercises. *National Athletic Trainer's Association Annual Convention and Symposium*. Dallas, TX, June 2002. Poster Presentation

**Silkman, C.** Gender Differences in Pain Tolerance and Pain Perception. *Senior Research Thesis Presentation Forum: 2000 Castleton State College, Castleton, VT*. Poster Presentation